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OF GEORGIA.

FIRST REPORT OF PROGRESS,

1890-91.

J. W. SPENCER, A. M.;
Ph. D. (Göttengen); F. G. S. (A. & L.);
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ADMINISTRATIVE REPORT.

ATLANTA, July 1, 1891.

To his Excellency, W. J. Northen, Governor, President of the Geological Board of Georgia:

SIR—Under the law reviving the Geological Survey of Georgia I was appointed State Geologist by your predecessor; and two assistants were appointed by the Board. Upon July 1, 1890, I assumed the duties of my office, with the assistance of Mr. C. C. Anderson, civil engineer, in charge of the hydrographic work of the survey, and Mr. E. T. Whatley, as Assistant Geologist. On July 2d, the Board met and adjourned until the 12th, in order to obtain bids for camp equipments, after which the outfits were procured as quickly as possible.

Under the law, two Assistant State Geologists, engineering and chemical work, as well as the outfits, were required. The appropriations were entirely inadequate. Nearly $1,700 have been spent in partial equipment, and over $1,300 in field and office expenses. Under the law, each officer was to have charge of a separate section of the State. But only one assistant could be provided for geological work, after the engagement of a necessary engineer, and only two field parties could be equipped. In order to overcome the stupendous difficulties of lack of funds, and give each section of the State a fair proportion of the labors of the survey, I have devoted nearly equal portions of my time in North and in South Georgia. The water powers, which are most largely situated in Middle Georgia, were entrusted to Mr. Anderson. Dur-

ing a portion of the year Mr. Whatley was attached to Mr. Anderson's camp, with instructions to conduct as far as possible a geological survey for ten miles on each side of the rivers, surveyed by Mr. Anderson; parts of Campbell, Coweta, Troup, Heard, Muscogee, Fayette, Clayton, Spalding and Upson counties. For a portion of the year, Mr. Whatley had one of the camp outfits, whilst Mr. Anderson or myself was engaged in office or field work, not requiring a wagon. During this time, he was working in counties south and west of Atlanta, surveying the whole of Harris, Talbot, Merriwether and Pike counties. By this method, the only one possible, I have given each section of Georgia such attention as the means would permit.

My own field work was as follows : A *reconnaisance* in Northwest Georgia preparatory to laying out the future work of the survey in that complicated section; a preliminary survey over Southwest Georgia, from the latitude of Columbus to the Floridian boundary, with a breadth of sixty miles; and a geological survey of Polk county, as the first of the county surveys in Northwest Georgia. In the *reconnaissance* in Northwest Georgia I traversed Fulton, Paulding, Polk, Floyd, Bartow, Chattooga, Walker, Dade, Murray, Gilmer, Lumpkin, White and Habersham counties. I had also previously twice crossed Bibb, Monroe, Upson, Meriwether and Troup, in geological explorations.

These explorations in Northwest and Middle Georgia gave me cross sections and outlines of the positions of the geological formations and the belts of ores. Owing to all of these districts having had their original strata disturbed by mountain movement of the earth's crust, I decided not to make a report for publication on insufficient data, and to wait for the surveys of the counties, having by this preliminary work been enabled to commence the

district investigations, deeming Polk county the most suitable as the basis of operations.

In making geological reports, the various States have adopted one or other of two methods: one in not publishing until a whole subject is completed, the other of publishing reports of progress followed by final reports. Whilst the law of Georgia requires a biennial report of progress, it does not require the premature publication of reports of scientific work. I accordingly submit such of the reports of progress as can be prepared at this early stage of the survey.

In the survey of geological formations, a group of structures is rarely confined to a district. Before the features or the relation of the resources of any county can be understood, the geological structure must be known, and hence considerable areas beyond that required must be examined. Consequently, the description applied to one county may be applicable to other counties, subject to local variations and local developments. Thus, the knowledge of the geological structure of Polk county greatly simplifies the investigations in Bartow, which closely resembles it. In the investigations of a region, the most difficult task is the first identification and commencement of work. I am gratified that it is possible to submit the first reports upon the districts surveyed, at this early date of the survey. Polk county is very rich in available iron ores, limestone (or tinted marbles), slate and other minerals, besides containing some of the best farming land in the State. For want of a chemist, the analyses of minerals and soils could not be made, and hence this portion of the report must be delayed.

Southwest Georgia does not present the disturbances and upheavals of Northwest Georgia, accordingly the survey of this larger area can progress more rapidly. Prac-

tically no scientific information, concerning this region was attainable, when the survey was commenced.

Whilst my camp equipment was being prepared, last July, I visited Thomas county and found that the phosphate deposits were of value, but there was no geological data to work upon, except such as I ascertained in the district. I was also consulted about artesian wells, but upon this subject no information could be given, as the character of the geological formations, and their extent were unknown. This great lack of knowledge caused me to give South Georgia my early attention, and in October the work was commenced, by a joint exploration along the Chattahoochee river, by the geological surveys of Alabama, the United States and Georgia, the officers being State Geologist Smith and Mr. Langdon, of Alabama, Mr. L. C. Johnson, of the United States Geological Survey, and the writer. Subsequently I spent several months in this work, descending the Flint river and making cross sections, which have enabled me to prepare a preliminary report accompanied by a general map. This work will serve as a basis of future operations, and covers more or less of Decatur, Thomas, Brooks, Mitchell, Miller, Early, Baker, Dougherty, Calhoun, Clay, Quitman, Randolph, Terrell, Lee, Sumter, Dooly, Webster, Stewart, Chattahoochee, Marion, Schley, Macon, Crawford, Taylor and Muscogee counties. This preliminary report was indispensable, as no small district could have been completely surveyed, for the general relations were not known; and the want of a chemist would have delayed the final report upon soils, phosphates and minerals, although it is the province of the geoloist to trace out the different formations.

Besides the time occupied in by field operations, a great deal of labor is required in concentration and digestion of facts collected, so as to mould order out of disorder and

make an intelligible report. Also much labor is consumed in map making. This is shown in the report of Prof. Little, former State Geologist, who records the fact that for four months, in 1875, the whole corps was engaged in office work, and ordinarily one officer was constantly in charge of the office. But our office has been closed most of the time, except from November to early February, and since that time it has been open for only a few weeks, whilst I was preparing reports.

Great numbers of inquiries have been made with regard to the mineral and economic resources. Amongst these I call especial attention to "Bauxite," one of the two minerals from which aluminum is extracted. This mineral occurs in Floyd county, and is also said to occur elsewhere. It will likely open up a new industry in Georgia. Already, I have put myself in a position to answer many questions concerning artesian water These are two classes of inquiries, which are recent, but most important. The healthful water supply, in South Georgia, is really a first question, even coequal with agriculture, and before minerals, such as phosphates, marls, etc. Not only the towns, but also many farms, can so obtain water, yet there are districts where search is useless The survey is now in a position to give the first steps towards advice upon the distribution of water-bearing beds.

I herewith submit a preliminary report upon Southwest Georgia, along with a map of the general distributions of formations.

Mr. Anderson was intrusted with the water powers, which are most largely situated in Middle Georgia. He has made the first survey of the powers along the Chattahoochee and Flint rivers and subordinate creeks, and is now engaged upon the Ocmulgee river. The report cannot be published as yet. In the survey of water powers, at arious points of discharge, the river must be examined at

different stages of the water, and water-stage meters must be read for a time, before valuable results can be obtained. An estimate, based upon one survey of the various shoals at the variable seasons, does not afford reliable information, and accordingly the results will not be offered at present; but the list of shoals will show that the work is in active progress. These powers will be reported as soon as sufficient data of fluctuations of the rivers shall have been obtained.

Mr. Whatley was intrusted with the geological surveys of certain counties southwest of Atlanta. His duties have kept him at field work without opportunities for preparation of his reports, except that of Pike county, which he has submitted to you. The progress of the surveys by all the officers has been reported to you at various times, but all the work is not ready for publication.

As chief officer, responsible for the accuracy and progress of the work, I have been greatly embarrassed for want of adequate and financial means to carry on the work in the most satisfactory manner. To obviate some of these difficulties, the Geological Board unanimously recommended certain changes in the law, which have also been unanimously recommended to the House by the General Agricultural Committee. The bill is still pending.

I have here to acknowledge to the advantage of Georgia, the survey of the Chattahoochee being made jointly by the interested States. I also acknowledge the assistance from the United States map of a portion of Northwest Georgia, by Mr. C. Willard Hayes, of the United States Geological Survey, which has greatly expedited my work. I have the honor to be,

Your obedient servant,

J. W. SPENCER, State Geologist.

A.

GENERAL OR PRELIMINARY

GEOLOGICAL REPORT

—ON—

SOUTHWEST GEORGIA.

—AND—

REPORT ON POLK COUNTY.

By J. W. SPENCER.

TABLE OF CONTENTS

IN REPORTS UPON THE GEOLOGY OF SOUTHWEST GEORGIA AND POLK COUNTY.

PREFACE.

Under the law creating the office of State Geologist, the different sections of the State are equally provided for, as to the amount of work that shall be done. The law also provides for such preliminary work in the different sections as may be deemed necessary. The purpose of the survey, as defined by the law, is to make known the physical character of the country, whatever is of scientific or economic value, and the agricultural and climatic conditions. Under this broad requirement of the Geological survey, I have devoted several months at investigations in southwestern Georgia, in that portion of the State south of the line drawn approximately between Columbus and Fort Valley, and the Florida boundary. This section of the State represents an area of about 7,500 square miles. The district is a natural division, as it embraces the whole breadth, from north to south, of all the geological formations present in South Georgia, newer than the Archæan crystalline rocks, which latter form the middle belt of Georgia. No authentic scientific information of this part of the State, whatever, had been obtained and preserved; consequently, the region was almost a *terra incognito*. The wisdom of commencing the survey of the southern part of the State from the western boundary has proved doubly wise. In the first place, the work was commenced where left off by the Alabama survey. In the next place, some of the formations, which are developed along the Chattahoochee river, narrow down to unimportant proportions in passing eastward. The investigations along the Chattahoochee river were jointly conducted by the officers of the surveys of the Border States, and by a representative of the United States Geological Survey, namely: Professor E. A. Smith, State Geologist of Alabama; Mr. D. W. Langdon, formerly of the Alabama Survey; Mr. Lawrence C. Johnson, of the United States Geological Survey, and the writer, as State Geologist of Georgia.

This river was found to be an exceptionally favorable line for geological exploration, as the waters have cut down the banks on one side or the other, so as to expose the subjacent rocks for almost its entire length.

In making a geological survey, the first investigations must be to obtain a knowledge of what formations are present, their characteristics and their distribution. No detailed work was possible in Southwest Georgia until after such a preliminary survey had been

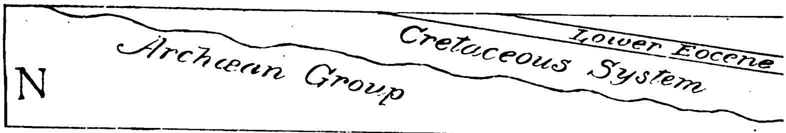
made, for the geologist could in no wise anticipate what he was next coming to. Such a general survey has now been completed, which will greatly facilitate not only the final surveys of that portion of our State, but be of assistance in carrying the work into Southeast Georgia. In this preliminary exploration, a less extensive investigation of the soils has been made than is required, partly on account of the survey not yet having been provided with a chemist; but some consideration of the question of soils is obtainable from their relationship to the sources whence they were derived,—information which can partly be obtained without the aid of chemical work.

My first official observations made in the State were upon the subject of phosphates of Thomas county. Going into the field, as was done, without a knowledge of the general geology of the southern part of the State, no generalizations could be carried beyond the immediate locality investigated, nor could the laws of the distribution be thereby determined; hence, the greater necessity for the completion of the preliminary work, which ought to be followed by a closely detailed examination. Another question of great importance is that of the supply of artesian water, for, up to the present time, I have found that the attempts to obtain such water-supply have been purely venture, without any intelligent pre-judgment. This could only be obtained after the country had been geologically surveyed.

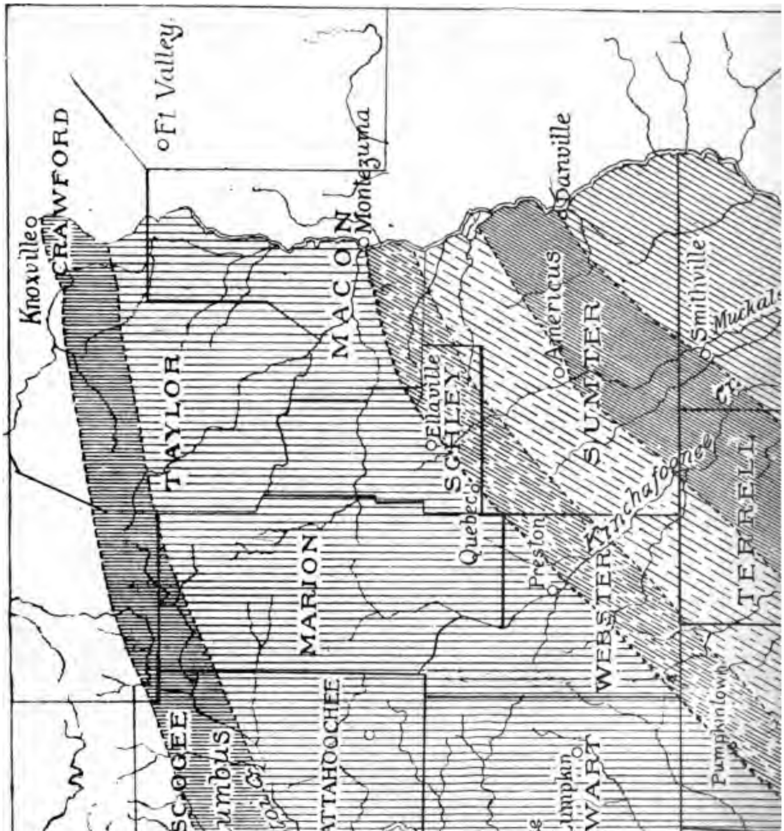
In the general exploration now finished, I have traced across the belt of South Georgia, sixty miles in width, the boundary between the great Cretaceous and Eocene systems, and have found a much greater development of the former than was formerly supposed; also, the leading subdvisions of the Eocene have been somewhat approximately determined, by which I am enabled to construct a general map of this portion of our State.

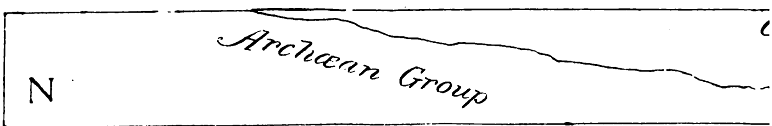
In the following report, the scientific considerations will be supplemented by those on the economic relations to the geological formations in that portion of the State.

Appended is a copy of the original report by Mr. Langdon, along the Chattahoochee, which was re-examined by the Joint Surveys. This record has permitted of some abbreviations in my report. The appended geological section greatly expedited the joint survey of the river, as well as the preparation of this report.



Meridional Section





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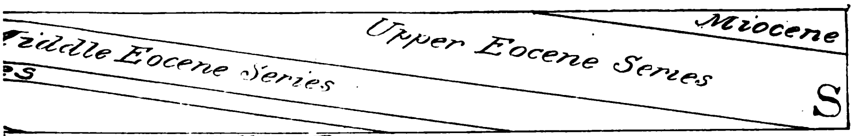
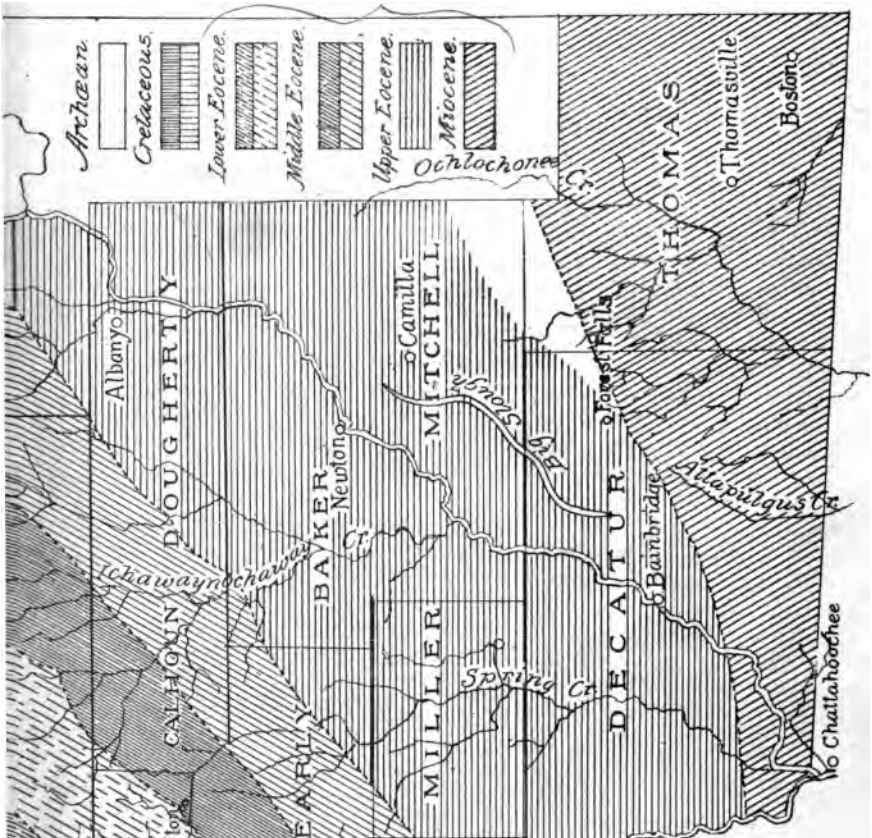
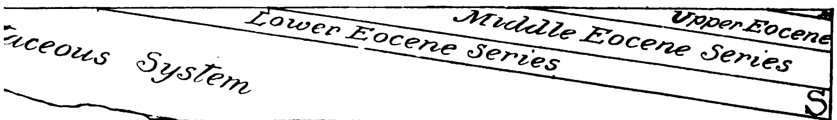


acent to the Flint River.





acent to the Chattahoochee River.

Tuscaloosa distinguished from remainder of Cretaceous; Midway from remainder of L. Eocene; Buhrstone from Claiborne (of M. Eocene); all by darker shades.

CHAPTER I.

GEOLOGICAL SYSTEMS IN SOUTHWEST GEORGIA.

Between the geological succession of strata which underlie the lands of the southern portion of the State, and the middle, there is a stupendous gap. The middle portion of the State is built out of crystalline rocks belonging to the oldest formations—the Archæan group. Resting unconformably upon them there are beds of clays, sands, marls, etc., often in an imperfectly consolidated condition. The line between such different materials is consequently easily defined and extends from Columbus to Knoxville and eastward. The section of the State under consideration is that portion lying between this southern margin of the Archæan belt just defined and the Floridian boundary, occupying about 7,500 square miles. Crossing the country, the different geological series succeed each other, in which there are inscribed the records of the building of Georgia, and the relations between the formations and the physical features; the soils; the material resources, and the habitability of the different localities; hence it is necessary to anticipate and tabulate the great geological groupings, which are represented in the southwestern portion of the State, in descending order:

Groups.	Systems.	Approximate thickness in feet.
Cenozoic. (Tertiary).	Pleistocene	150 feet.
	Pliocene	Doubtful.
	Miocene	300 feet.
	Eocene	1500—1600 feet
Mesozoic. (Secondary.	Cretaceous	1645.
	Jurassic	Doubtful.
	Triassic	Absent.
Palæozoic. (Primary).	Permian	"
	Carboniferous	"
	Devonian	"
	Silurian	"
	Cambro-Silurian or Ordivician.	"
	Cambrian	"
Archaean.	(As yet not differentiated into systems in Georgia)	At base.

CHAPTER II.

THE GEOGRAPHICAL FEATURES.

The topographic features of Southwest Georgia bear a strong contrast to the mountainous portions of the State, but its uniformity disappears upon closer inspection; for whilst across it no mountains have been upheaved, yet the different rivers have moulded portions of the country into a succession of hills and deep valleys, obliterated and partly filled the valleys which they have made, or have left other districts almost unscarred. This sculpturing of the country by the rivers has not been continuous, but has been interrupted by many geological changes, during which land surfaces of one epoch have been buried beneath the materials of the succeeding, primarily derived from the wearing away of the Archæan formations during the great portion of geological time, when the Palæozoic and most of the Mesozoic systems were being formed elsewhere beneath the sea, above which Georgia rose as the southern extension of a long island.

The marginal portion of the metamorphic country consists of a succession of broad, rounded hills passing into rounded valleys without the abrupt features of newly made mountainous countries. One series of hills succeeds another, yet, deceiving the eye, they are found to vary but little in height. This ancient and softened topography forms the character of the country just north of the section upon which this report treats, seldom rising higher than 700 feet above the level of the sea, and in the valleys of the Chattahoochee and Flint rivers to about 250 feet.

The country south of the metamorphic line presents quite a different appearance. Commencing with a similar altitude, there is a succession of high plains, rising in places to about 700 feet above the tide, but deeply incised by the succession of rivers and streams, which have frequently carved down the abrupt valleys, as the streams have not yet reached the "base-level" of erosion. Thus the country is often more rugged than the older metamorphic zone to the north. Whilst the general altitude of this sculptured plain descends southward, yet the streams have carved out valleys often to as much as 200, and sometimes 250, feet beneath the adjacent plains. The excavations of deep valleys through the plains is more pronounced in the vicinity of the Chattahoochee and the Flint than farther away from

these great rivers. Still, this striking topography bears a close relationship to the distribution of the Cretaceous system, whose lower margin is not any more elevated, but has been longer exposed to the corroding action of meteoric agents than the more southern formations of the Eocene period. This contrast is most perceptible in the streams distant from the great rivers, for, where distant from the great rivers, the streams in the Eocene country are flowing in shallow depressions, but those of the Cretaceous are flowing in deep valleys. The Cretaceous country, approximately north of the line from near Fort Gaines to Montezuma, may be briefly defined as consisting of extensive high plains traversed by deep, narrow valleys.

From the descending margin of the Cretaceous belt, the features of the country, underlaid by the Eocene formations, gradually become less pronounced, and although the maximum elevation may reach 500 feet, yet it commonly descends to lower levels. The northern marginal portion of the Eocene country is characteristically a belt along which small lime-sinks are common. These often form ponds or lakes. Further southward, except adjacent to the great rivers, the Eocene plains are rarely sculptured by valleys deeper than fifty or sixty feet. The country underlaid by the lower portions of the Eocene system is watered by numerous streams. The southern limit of this belt may be approximately drawn across Lee, and the northern portion of Calhoun and Early counties. South of this line the country is underlaid by formations which belong to the middle and upper Eocene series, which have affected the topographic features. Over this belt much of the country is remarkably level and interrupted by few streams, as the rainfall is often carried off by subterranean passages, through underlying, cavernous limestones, hence the absence of numerous small valleys. This broad belt of country is further characterized by lime-sinks, ponds and occasional sloughs, and has an elevation from 170 to 250 feet above the sea. These sloughs are simply the depressions of the broad plains, whereon the water accumulates during rainy seasons, owing to the imperfect, superficial or otherwise subterranean drainage. The largest of these depressions is that of the great slough through Mitchell and Decatur counties, which is over thirty miles long. It is apparently a broad, flat plain, when not covered with water, from one to two miles wide, with occasional ponds. During extremely wet seasons this lowland becomes flooded and overflows into the Flint river, near Bainbridge. Under the subject of Drainage this region will be referred to again.

Small branches frequently flow into the sloughs and ponds and are then lost. The waters of some of these ponds are healthful, clear and deep. Many ponds are evanescent—their periodicity varying from wet seasons to even several years, when their subterranean outlets become closed to be again suddenly reopened. In several

cases seen, the lime-sinks are not filled with water, as the streams run out as fast as they enter. The most remarkable of these sinks, is in the northeastern portion of Decatur county, at Forest Falls. Here is a lime-sink 100 yards long, with a base of the bowl about 60 feet in diameter, having some small caverns opening into it. Into this pit a permanent stream descends, at first by rapids and then cascades 90 feet over a fall into the pit, whence it flows into a subterranean passage. The floor of the pit is only 70 feet above sea-level, although situated more than as many miles from the Gulf of Mexico. Many similar cascades were seen, sometimes falling into lakelets and sometimes into empty pits.

Passing from the Eocene to the Miocene regions, in Decatur and Thomas counties, the country again attains a higher elevation, reaching from 250 to 300 feet above the sea, and it is traversed by valleys from 50 to 80 feet deep, or more, as they approach the Chattahoochee river. Over this more elevated and rolling country there is an absence of lime-sinks, but another belt is again met with in Florida and the southern part of Thomas county.

The topographic features along the Chattahoochee and Flint rivers need some special notice.

In the growth of the State, these rivers have been developed from the north towards the south. These early valleys were much greater than at present, and were formed when the whole region was vastly higher than it is to-day, as shown in another paper by the writer.* The continent then stood at an elevation of 3,000 feet or more above the present altitude. During this high continental period the Chattahoochee valley, in Muscogee and adjacent counties, cut out its broad valley from one to two miles or more in width and to a depth of 300 feet or more; whilst the Flint valley, in Crawford county, with a breadth somewhat less, was reduced to 150 feet below the general plain. By the subsequent changes of the land and sea the great valleys were, to a limited extent, refilled with sediments, so that we now find between the elevated plains and ridges bounding the rivers, high-level-terraces belonging to the valleys. The highest and most perfect of these broad terrace plains is about 100 feet above the river at Columbus, or 260 feet above the sea. Whilst this plain has been to a considerable extent eroded, still it forms a conspicuous feature, often a mile or more in width and maintaining a nearly uniform height, extending down the river to beyond the Georgia boundary. In the southwestern corner of the State this terraced plain has an elevation nearly equal to that of Columbus, rising to 255 feet above tide, or about 175 feet above the river.

Along the Flint river, in Macon county, there are extensive plains

*High "Continental Elevations preceding the Pleistocene Period," by J. W. Spencer. Bull. Geol. Soc. Am., 1889.

at 200 feet above the river, but these are not confined to the river valley. Lower terraced plains are met with farther down the river, and are well represented by the plain whose elevation at Bainbridge is 118 feet above the sea, or about 60 feet above the river.

Whilst, adjacent to both rivers. fragments of lower terraces are seen, especially along their lower reaches, there is a marked difference in the topography of the two rivers. The erosion and scouring out of the Chattahoochee channel has been vastly greater than that of the Flint, and as a consequence, the waters have carved their way through all of the sediments filling the ancient valley, so that along the water's edge, and in the bluffs which generally bound the river, exposures of the more ancient sediments are nearly everywhere seen; until the river enters Decatur county. There the bluffs recede from the river and the low bottoms are liable to be flooded. Above this county there is a comparatively small development of low bottoms, which are liable to overflows. The higher terrace-plains are rarely reached except by extreme floods, which have been known to rise at one point to nearly sixty feet. The features of the Flint river show a strong contrast; there, the erosion has not cut down the channel below the broad, low flood plains to any great extent. The stream generally flows through broad bottoms nearly a mile wide, and only rarely washes against and exposes the bluffs which bound the ancient valley. Hence, for geological investigation, the exposures along this river are inferior to those along the Chattahoochee; but there is also an economic bearing, for these lowlands are apt to be flooded by an ordinary high water, as in many places the channel is not over 15 feet deep. In some places the swamps are broad and very extensive especially in the upper portion of the valley. From a point, a few miles above Albany, the features somewhat change, and the river cuts a deeper channel in the upper Eocene rocks, leaving flood plains less liable to be overflowed than farther north. In this lower portion of the river there is also a large number of rock exposures, but at only one or two points are shoals formed, which materially affect navigation. Here, in the lower portion of the river, we find that the base-line of the erosion has been somewhat lowered, like the Chattahoochee, but the hard limestones, in the region of Lee county and below, have not yet permitted the general subsiding of the river level above that point, and hence the greater liability of overflows along the upper portion of the river.

At no point, above Albany, does the Flint river cut its channel wholly out of the Eocene rocks, for even where such are exposed, they appear only on one side or the other as a great proportion of the banks is excavated out of the superficial capping of sands and clays belonging to the Lafayette and Columbia formations, which will be noted later. Below Albany, however, there are several points where

the modern channel cuts directly across the Eocene limestones, although a greater portion of the banks of the lower reaches of the river are formed of the loose deposits, which occupy the ancient valley. The general characteristics of the Chattahoochee and Flint rivers do not assimilate until a region, a few miles above their junction, is approached, where the boundaries of both rivers are low lands, with bluffs receding to a distance. Whilst the Chattahoochee river cuts almost directly across hard calcareous rocks of the middle and upper Eocene formations, below Big Creek, in Early county; the Flint enters a country of the same character, near Danville in Sumter county, and flows diagonally across the same formations to near its mouth, thus passing over a vastly greater distance of hard materials which are more slowly excavated than those along the Chattahoochee. Along the Pataula, Upatoi and some other creeks entering the Chattahoochee, the streams are characterized in part by high bluffs favorable for geological exploration. Along the upper waters of the Ichawaynochaway, Kinchafoonee, Muckalee and Spring creeks, their valleys are unimportant, and often swampy without any great exposures of rocky banks; Such, however, rise into bluffs along their lower reaches, where limestones and marls form an important feature. In the southern part of the State, the Attapulgus and portions of the Ochlockonee and other streams observed, flow over low ground which is often swampy, with the bluffs situated not immediately upon the streams.

The topographic features of the southwestern part of the State are not difficult to understand. The elevations have been taken from such railway levels as were available, and from these points the supplemental determinations were constantly being made by the use of the aneroid barometer. From such data, the generalized description above given has been drawn; however, for further guidance, the railway levels available are here added. In some cases, the roads follow the water sheds, and there the altitudes represent the highest land. In other cases they follow the valleys; here, then the elevations represent low depressions, as for instance, in the case of Americus, where neighboring hills rise one hundred feet above the railway.

The highest lands, in southwest Georgia, extend, with some interruptions, from near Fort Valley, southwestward to Stewart county, the highest point being in the northeastern corner of the county at Brooklyn Station, on the Columbus Southern Railway, where the altitude reaches 691 feet.

Of the elevated ridge crossing the southern portion of Decatur and Thomas counties, Faceville is the highest point, with an altitude of 304 feet above the sea. Thomasville is situated a few feet above the railway elevation given (258 feet), and Whigham and other points to the west are somewhat higher.

The relationship between the topographic and geological features, is such that it has been necessary to give this brief outline before consideration of the geological structure of the country; also there is a close relationship between the topographic and agricultural features and habitability, which subjects will be considered in their proper places.

ELEVATION TO ACCOMPANY PRELIMINARY GEOLOGICAL REPORT ON SOUTHWEST GEORGIA.

Station.	Elevation above Sea.	Authority.
Waycross	145 feet	S. F. & W. Ry.
Glenmore	159 "	"
Argyle	169 "	"
Homerville	124 "	"
Dupont	188 "	"
Stockton	196 "	"
Naylor	200 "	"
Valdosta	223 "	"
Ousley	156 "	"
Quitman	181 "	"
Dixie	139 "	"
Boston	202 "	"
Thomasville	258 "	"
Cairo	246 "	"
Whigham	273 "	"
Climax (Bainbridge Junction)	285 "	"
Bainbridge	118 "	"
Fowltown	297 "	"
Faceville	304 "	"
Recovery	197 "	"
Chattahoochee Junction	78 "	"
Camilla	170 "	Butt's Map.
De Witt	175 "	"
Humboldt	180 "	"
Albany	189 "	Central Ry.
Albany	172 "	Bruns & W. Ry.
" Valley of Flint	154 "	"
" Surface of water	127 "	"
East Albany	186 "	"
Macon	334 "	M. & B. Ry.
Seago's	362 "	S. W. Ry.
Byron	515 "	"
Fort Valley	522 "	"
Marshallsville	492 "	"

Winchester	465 (?)	377	S. W. Ry.
Montezuma	300	feet	"
Flint River Bridge	305	"	"
Oglethorpe	300	"	"
Andersonville	396 (?)		"
Americus	348	feet	"
Smithville (83 miles)	319	"	"
Kinchafoonee Bridge	265	"	"
Dawson	326	"	"
Nochway Bridge	283	"	"
Pachitla	340	"	"
Cuthbert	452	"	"
Cuthbert Junction	469	"	"
Morris	235	"	"
Fort Gaines	152	"	"
Fort Gaines, River Surface	100	"	(about).
Georgetown	189	"	"
Eufaula, Ala	211	"	"
Ellaville	591	"	"
Knoxville	640	"	J. E. Thomas.
Columbus	260	"	Col. So. Ry.
Bull Creek	240	"	"
Upatoi Creek	225	"	"
Ochillee	289	"	"
Cusseta	532	"	"
Manta	515	"	"
Top of cut at Manta	565	"	"
Green Hill	601	"	"
Brooklyn	691	"	"
Richland	600	"	"
Weston	528	"	"
Parrotts	482	"	"
Dawson	376	"	"
Sasser	336	"	"
Oakland	275	"	"
Palmyra	260	"	"
Albany	208	"	"
Upatoi	432	"	Cent. Ry.
Geneva	600	"	"
Bostwick	669	"	"
Butler	650	"	"
Reynolds	433	"	"
Flint River	337	"	"
Everett's	362	"	"
Fort Valley	522	"	"

The above outline of the topography of the section investigated was necessary for easy understanding of the geological features, for although a consequence of the geological structure and forces, yet only from the study of the features can we determine whether or not the region is favorable to the preservation and investigation of the geological relations. From what has been already stated, we learn that the exposures along the Chattahoochee are exceptionally favorable for geological study, whilst those along the Flint are somewhat less so; even the scanty information from artesian and other wells, has enabled me to mould into order, the information obtained from the river sections and superficial cuttings along the railways.

Most of southern Georgia is covered by a superficial sheet of earthy matter, which conceals the underlying formations, and constitutes the soils. This mantle varies in character, and will form a distinct subject of consideration.

By the study of the accurate topography and dip of well characterized formations, the geologist can predicate their distribution and extent over considerable areas, and have some knowledge of the interior of the earth's crust, even when the same is not directly observable. But formations often change in composition and character. Sometimes they thicken or again thin out and disappear, so that in widely separated areas, the records will not be identical; but in Southwest Georgia the great formations maintain their general characteristics over considerable areas, although in some cases they become narrowed in passing eastward. As the dip of the rocks is very gentle, the same series or formations are apt to underlie broad belts of country.

CHAPTER III.

THE CRETACEOUS SYSTEM IN SOUTHWEST GEORGIA.

The positions of this assemblage of materials in the geological grouping have already been noted in the table on page 17. In other regions the Cretaceous strata are more extensively developed than in the Southern States. In the Eastern and Southern States, there are two large Cretaceous basins which are separated by portions of Georgia. The Atlantic Cretaceous basin extends from New Jersey southward. The Gulf basin crosses the Southern States and enters Georgia with a breadth of about fifty-seven miles along the Chattahoochee river; it, however, diminishes to a width of about twenty-four miles along the Flint river, eastward of which it is of small extent. In their study, these strata must be considered in their relation with the deposits of Alabama and westward.

The subdivisions of the Cretaceous system in the Gulf States, adopted by Dr. E. W. Hilgard, of Mississippi, in 1871, and followed by Dr. E. A. Smith, of Alabama, is represented in descending order, in the following table:

Series.	*Estimated thickness in feet.*
Ripley	250–275
Rotten Limestone	1,000
Eutaw (Coffee)	300

At the base of these series, Dr. Smith added (with some question):

Tuscaloosa	1,000

This classification will be adopted in the present report.

Crossing the Gulf States, the formation undergoes a most notable change in the disappearance of one thousand feet of Rotten Limestone on approaching the Georgia boundary. On the other hand, the Ripley series undergoes a great thickening, from less than three hundred feet to nearly eleven hundred. Again, the Tuscaloosa series undergoes a shrinkage. This change is observable in comparing the above table with the succeeding section along the Chattahoochee river, first determined by Mr. D. W. Langdon.

SECTION ALONG THE CHATTAHOOCHEE RIVER.

Ripley Series	1,080 feet
Rotten Limestone	Wanting
Eutaw Series	385 feet
Tuscaloosa Series	180 feet

These Cretaceous deposits extend along the Chattahoochee from Columbus to a point about eight miles by river, north of Fort Gaines, and near the mouth of Sandy creek. In the region of the Flint river, the beds extend from Knoxville, Crawford county, to a point along the river about three miles above Montezuma, a distance of about twenty-four miles, although to the east of this meridian, the Cretaceous formations occupy a much narrower belt. The southern boundary of the system may be defined by a line drawn approximately between these points, passing near Ellaville, Quebec, Preston and Pumpkin Town. In drawing such a comparatively straight line across a map to represent the boundary between two formations, the topographic features, of necessity, modify its directness. Thus, where the lines cross deep valleys, the lower formation are found near the approximate line given, whilst unusual elevations of the land, cause the upper formation to extend in the opposite direction. Whilst the dip of the rock varies, sometimes appearing almost horizontally, and again increasing to one hundred feet per mile, yet the general average is reduced by return dips, whereby the same beds appear exposed for considerable distances along the river. The general average dip of Cretaceous formation, I have placed at twenty-five or thirty feet per mile towards the south southeast.

THE TUSCALOOSA (POTOMAC) SERIES.

Resting upon the deeply sculptured surface of the upheaved metamorphic rocks in central Georgia, there is a series of unconsolidated white, yellowish, gray, green or purple micaceous sands, gravel, and purple and mottled clays. The sands are often coarse, and held together with clayey matter. Sometimes they are strongly cross-bedded. These sands frequently resemble decayed gneiss so closely as to render mistakes liable when they do not contain rounded pebbles. Where gravel beds are developed, the pebbles are well rounded and water-worn, and commonly are composed of quartz, derived from veins in the metamorphic rocks of upper Georgia. In some localities the clay is white and kaolin-like, but it is often stained lemon color, along the lines of joints, by iron compounds, thus producing a mottled appearance. In many exposures this kaolin-like clay resembles pockets, or beds of decomposed feldspar, of the adjacent metamor

phic rocks. In valleys, both near Columbus and Knoxville, and elsewhere, the resemblance between these different clays is so strong that the observer must reassure himself of their true origin.

Such is the character of a series of deposits forming a belt, about eight miles wide, extending from Columbus to Broken Arrow Bend on the Chattahoochee river, where they are overlaid by fossiliferous beds of the Eutaw series. Such deposits are seen in exposures up to nearly one hundred feet above the river, near Columbus, and thence, down the river bed. The mottled clays are particularly well shown in the railway cut, opposite Columbus on the Alabama side of the river. Two or three miles above the mouth of the Upatoi creek, near the wagon-bridge, there is a fine exposure of these deposits in descending order, thus:

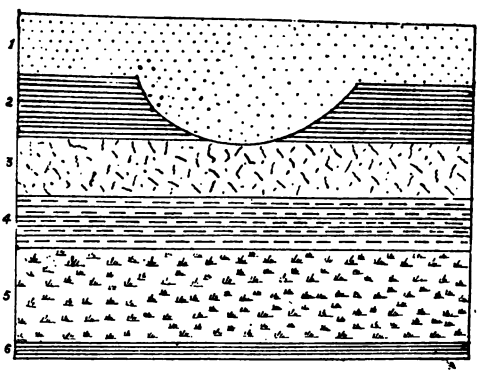


FIGURE 1.

1. A superficial covering of Lafayette deposits upon the sculptured surface of
2. Irregular laminated colored sands with streaks of white sandy clay..... 6 feet.
3. Coarse white and mottled sand with clayey binding..... 8 feet.
4. Gray sandy clay..... 6 feet.
5. Concealed..... 10 feet.
6. Dark gray, nearly black clay exposed..... 2 feet.

The surface of the formation under consideration is seen in many exposures where its surface has been carved out by streams, and again covered by recent geological deposits.

On the sides of the hills north and west of Knoxville, fragments of this series of deposits remain, but the mottled clays are not easily

distinguishable from the decomposed feldspar of the older deposits, but some of the layers are composed of coarse sand or grit containing a small portion of argillaceous matter. This geological formation probably extends southward to a line two miles south of Gaillard's Station, where purple mottled clays are unconformably overlaid by various beds of sands and clays referred to in the Eutaw series.

In the ravine, at Rich Hill (see figure beyond), about six miles southeast of Knoxville, the lower part of the section in descending order, consists of:

Light colored gray sand. ....10 feet.
White micaceous sand..... ..... 30 feet.
White kaolin-like clay with uneven surface exposed.....10 to 15 feet.

These beds underlie Eocene limestone and the two lower beds probably belong to the formation under consideration. The average width of this formation, between the Flint and Chattahoochee rivers, may be given at about eight miles. It is also seen at Macon, but that locality is outside of the section under consideration.

These deposits have an estimated thickness of 175 to 200 feet. Farther west than Alabama, Professor Smith estimates the formation at 1,000 feet. It represents the first materials deposited after the enormous lapse of geological time, during which Middle Georgia formed an island above the sea, lasting throughout the greater portions of the Palæozoic and Mesozoic eras; but with the subsiding of the land in the later Mesozoic times, the materials, washed off the high-lands, were deposited in the neighboring sea along the receding shore line now represented by this belt of sandy and clayey deposits crossing Western Georgia in a belt of eight miles in width, although, in Alabama, their breadth reaches twenty-three miles, and further east in Georgia diminishes to small proportions, or perhaps may disappear.

These deposits in Georgia are the eastern extension of a large series, named the Tuscaloosa by the Geological survey of Alabama. They are probably identical with the Potomac series of the middle Atlantic States, of Mr. W. J. McGee. That they are older than the lower Cretaceous beds of the Eutaw series, is apparent, for these latter succeed them in Alabama and Georgia; but there is some uncertainty whether the Tuscaloosa series should be regarded as belonging to the lower portion of the Cretaceous or the upper portion of the Jurassic system, owing to the scarcity of fossils in their clays. The plant remains, found in Alabama, favor their correlation with the Cretaceous system, which is provisionally done in this preliminary report without stating the evidences.

The surface of the country, underlaid by these sands and clays,

which are often derived from them, is usually covered by heavy sand, except where the last are overlaid by Pleistocene clays, as along the plains of Columbus.

These sandy beds are water-bearing, and from beneath the layers of clay, springs are apt to flow; thus the ravine, which cuts into Rich Hill to a depth of 135 to 150 feet, has risen largely from the undermining of the beds by such springs.

The white clays require chemical and further investigation, as some of them may prove of value in pottery manufacture, as similar deposits in New Jersey have done. The clay at the base of Rich Hill series appears to be of fine quality, and in part covered by only eight or ten feet of sandy deposits.

THE EUTAW SERIES.

Overlying the Tuscaloosa series, the fossiliferous deposits of the Eutaw are found. The greater proportion of this formation consists of clayey sands often cross-bedded with less important beds of pebbles. Alternating with these silicious deposits, there are laminated beds of clay and sand. Some of these layers are indurated and characterized by large concretionary balls. This last feature is notably the case in the dark green pyritiferous calcareous clayey sands at Broken Arrow Bend on the Chattahoochee river, near the base of the Eutaw series. Another striking feature of these beds consists of the sudden transition in the material character of the deposits; thus beds of sand suddenly thin out and disappear, or pass into layers of pebbles; the laminated clays may change their character and be continuous with even cross-bedded sands. This change from laminated clay to sand is seen above the mouth of Uchee creek, and just below the mouth of Rooney's Mill Creek, along the Chattahoochee banks. The transition is well seen in the railway excavations about two miles south of Gaillard's Station (Mr. McCarthy's farm), where dark bituminous clays, with micaceous sandy partings, pass into gray sandy clays, and where sandy partings suddenly increase from a few inches to many feet in thickness; hence, we do not find two neighboring sections showing the same succession of materials. Thus, in three excavations, all within a quarter of a mile, the following sections are shown; the layers being given in descending order:—

FIGURE 2.

Capping of red loam on an irregular surface of purple, white mottled clay.

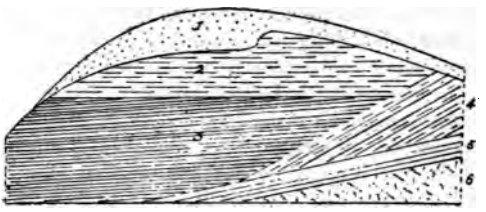


FIGURE 3.

1. Deep colored red loam upon an eroded surface..... .....0 to 4 feet.
2. Horizontal laminated, grayish clays, with red sandy partings..... .....10 feet.
3. Dark colored green laminated clays, with micaceous, coarse white sandy partings, dipping 15 degrees at south end of section, 6 feet, at north end..... .....12 feet.
4. A wedge of red sand rising from beneath the southern end of the last bed and attaining a thickness in the next section of..... .....10 feet.
5. Seam of white clay, with red sandy partings, underlying No. 3 and No. 4, average ....3 feet.
6. Deep colored purple and white mottled clays, exposed at the end of the section..... .....4 feet.

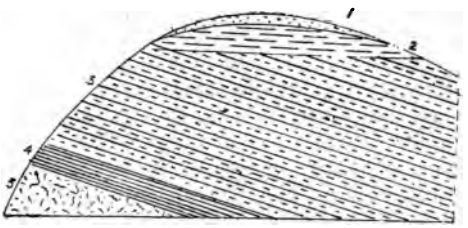


FIGURE 4.

1. Thin coating of red loam..... .....
2. Horizontal laminated grayish clay..... ..... 4 feet.
3. Deep colored red sand, with some white and red laminated sand below, with white clayey partings throughout a portion of the mass. Dip 10 degrees to the south; maximum thickness .....20 feet.

(This is an enlarged part of No. 4 of last section.)

4. Seam of white clay, with red sandy partings..... 3 feet.
5. Purple and white mottled clays, exposed at one end of section ..... 3 feet.

In these and other neighboring sections, the only persistent layer appears to be the underlying purple and white mottled clay. This absence of persistent beds adds to the difficulty in exploring the formation. The constantly variable character evidently points to the formation of these mechanical deposits in rapidly changing currents, and in shallow water. Along the Chattahoochee river, examples of quartzose pebbles or conglomerates are seen at Hatcher's Lower Landing and just below Chimney Bluff.

Throughout the Eutaw sands and clays, along the Chattahoochee, calcareous rocks do not appear, except in so far as fossiliferous sands may have been rendered calcareous.

Some of the intercalated, arenaceous layers of this formation contain glauconitic or green sands.

The lower portion of the Eutaw series is well characterized by fossils, as at Broken Arrow Bend, where the indurated sands contain an abundance of *Amonia* and small *Exogyra*. Near the upper portion of the series at Chimney Bluff, species of Exogyra is also found, but generally speaking, elsewhere throughout the series, fossils have not been observed, except lignitized wood, twiggs or leaves, which occur at several localities. Chimney Bluff, situated opposite Oswitchee Bend, and in the south-western part of Chattahoochee county, forms an exceptionally favorable exposure of the upper part of the Eutaw series. This bluff rises about 60 or 80 feet above the river, and owing to extensive land-slides, a characteristic feature of some of the Eutaw beds, the yellow sands and clays are well exposed. Near the base, lignitized logs were seen protruding, and some excellent layers of fossilized leaves. Just below the bluff there is an included bed of rounded, quartzose pebbles.

Although not yet observed along the Chattahoochee, it appears that in the upper members of the Eutaw series, in Alabama, there have been found indurated, calcareous sands, containing nodules of nearly pure phosphate of lime, phosphatized shell casts, and phosphatic matter in the sand itself. But these beds may possibly be related to the Rotten Limestone series.

The probable northern boundary of these strata is recognized about two miles south of Gaillard's Station, in the sections already noted. Another section about four miles southwest of the last named locality is seen at the western end of the approaches to the Southwestern Railway bridge over the Flint river, east of Reynold's Station.

(Section.)

1. Orange loamy sand passing into.....12 feet.
2. Water-worn quartz gravel, mostly under 1¼ inches in diameter .....10 feet.

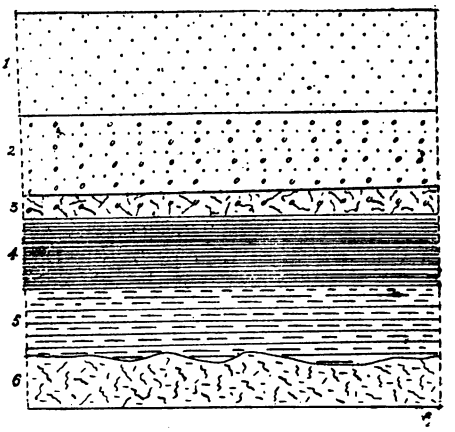


FIGURE 5.

3. Light blue clay..... 3 feet.
4. Banded clay..... 4 feet.
5. Red and white banded sand, resting unconformably on.....6 feet.
6. Purple clay (with eroded surface exposed)..... 6 feet.

The beds Nos. 3, 4 and 5 probably belong to the Eutaw series.

The only other exposure of Cretaceous deposits seen along the Flint river is at a point about two miles below Everett's Station, where there is an important bluff showing the following beds in descending order:

1. Orange loam..... 8 feet.
2. Bluish white clay, with irregular joints stained red..... 6 feet.
3. Orange and gray clayey sand, with unconformable base on.....5 to 9 feet
4. Rough, whitish blue clay, surface and base both unconformable.....6 to 3 feet.
5. Orange stained rounded quartz gravel.....10 feet.
6. Coarse, cross-bedded white sand, with argillaceous binding, exposed..... 4 feet.

The lower three members of this section are Cretaceous and probably belong to the Eutaw series. For nearly a mile the bluffs expose these materials, and the dip is apparently not over twenty-five

or thirty feet per mile. The springs flowing through the lower gravel and sands have excavated several horseshoe recesses into these almost vertical bluffs. No attempt has so far been made to determine, in this meridian, the southern limit of the Eutaw series; nor, indeed, to trace its southern boundary hence, across the country to the Chattahoochee river.

Along the Chattahoochee river the Ripley formation extends from Broken Arrow Bend to Fitzsimmons' Landing, thus occupying a belt of about twelve miles. The assumed dip of this formation has been taken at about thirty feet per mile towards the south-southeast, and consequently the thickness closely agrees with Mr. Langdon's estimate of 385 feet. Hence, it will be seen that there is no great change in the volume of the Eutaw, in passing from Alabama to Georgia.

THE ROTTEN LIMESTONE SERIES.

This is one of the most pronounced formations of the Cretaceous series in Alabama, and is composed of impure limestones, at times merging into calcareous clay. In places, it contains an abundance of fossils. The limestones form marked bluffs along some of the Alabama rivers. The series has a thickness estimated at 1,000 feet. But along the Chattahoochee river, this great calcareous formation is absent, or at most, cannot be represented by more than an insignificant development of mechanical deposits, not yet identified.

THE RIPLEY SERIES.

Succeeding the more or less incoherent and prevailing sands of the Eutaw formation, there is an enormous thickness of impure, clayey sands or sand clays, often micaceous, and in some places of dark and in other localities of light color. Many of the layers are traversed by ledges of indurated rocky matter of similar composition, weathering into bold relief. Other beds of similar appearance are highly calcareous, from the occurrence of an abundance of fossil remains, which are occasionally preserved intact. Some of these deposits form considerable beds of calcareous marl, but none of them assume the condition of limestones. The marls are often highly phosphatic, as indeed some of the sands, which are occasionally glauconitic. Generally speaking, the sands are not incoherent, and contain enough calcareous or argillaceous matter to render them compact. Some of the sands are hardened into sandstones. Occasional gravel deposits assume the form of conglomerate. The general character of these beds is harder and more argillaceous than the materials of the under-

lying Eutaw formation. This aggregation of fossiliferous beds, containing upper Cretaceous fossils, has been named he Ripley series.

Along the Chattahoochee river, the Ripley series commences below Fitzsimmons' Landing, and the lower beds are composed of indurated, gray, calcareous, sandy clays, with intercalated bands, containing ball-like concretions. These deposits form bold, steep banks, into which the streams sometimes wear recesses. Such is the general character of the bluffs from Fitzsimmons' Landing to near Florence, a direct distance of eight or nine miles, although by river, more than twice as far. Whilst these beds dip gently to the south, yet they are frequently brought to view again by return dips, thus producing gentle anticlinals and synclinals. At many places, species of *Exogyra* are found, as these are the most common fossils. At the bend in the river at Patterson's, below Cottonton Landing, an abundance of large *Exogyra* was obtained. In some localities, the shells are not preserved in a perfect state, but yet are recognizable. Those clayey deposits of the lower portion of the Ripley are succeeded above Florence by more sandy strata, which are often concretionary.

At Rood's Upper Bend, a short distance above Roanoak, there is a most favorable bluff for the collection of fossils. Here is a section of marl, sand and clay, greenish gray clay, glauconitic sand and shell marl, forming an exposure of beds more than thirty feet in thickness. Of these layers, the glauconitic sand occurs near the centre of the series and has a thickness of about ten feet. When the indurated sands weather, quantities of fucoidal stems and coprolitic masses are found upon the hillside. In the lower beds, quantities of the teeth of shark, and the teeth and plates probably of reptiles, and fragments of lignite occur. The shell marl of the upper portion of the section is composed of a mass of decomposed shells of numerous species, with phosphatic nodules and occasional pieces of lignitized wood.

About a quarter of a mile below the fossiliferous bluff, there is a bed of oysters of gigantic size, the species of which have not been determined.

From this point for several miles, to near the mouth of Cowikee creek, the steep bluffs consist of light gray or green stained sands, indurated with calcareous or clayey matter. These somewhat hardened beds are followed by less coherent, impure sands. About six miles above Georgetown, just below the mouth of Soapstone creek, Stewart's Bluff rises to a height of 265 feet above the river. The lower 145 feet of this hill, is composed of Cretaceous strata; those exposed being dark green micaceous adhering sands. The Cretaceous beds are again shown opposite Georgetown in the Eufaula Bluffs, where the dark gray calcareous sands contain ledges of concretionary boulders of harder materials. Some of these strata are fossiliferous and descend to the water's edge, appearing at Burnett's Landing, on

the Georgia side of the river. Here were found quantities of *Exogyra costata* and the large shells of *Gryphæa mutabilis*. Below this point follows a succession of gray yellow sands, occasionally calcareous or argillaceous, and with sometimes indurated layers. Some of the beds contain Ripley shells and lignitized wood. Such were found in the argillaceous sands at the mouth of Pataula creek. Farther down the river, there is a ledge of sand, hardened into sandstone and containing *Exogyra costata* and *Echinoids*. This last bed is seen at the surface, for a considerable distance, owing to the return dips. The Echinoids are most abundant at the mouth of a small branch cascading over the sandstone, a short distance above Otho, Alabama. Just below the last named exposure, upon the Alabama side, at a point where the stream falls over a high bluff, there is a dark sandy micaceous and bituminous clay, in which friable fossils are delicately preserved, amongst which was a beautiful specimen of *Ammonites*. This bed is overlaid by a stratum of shell marl, containing numerous fossils, which is best seen upon the Georgia side, nearly opposite to this fall. The clayey sands containing *Exogyra* were found for two or three miles below Otho. Over these beds succeed coarse conglomerate, followed by a few feet of massive blue clay, which, at a point a little above Sandy Creek, Clay county, has been accepted by the joint surveys, as a summit of the Ripley series, and indeed, of the Cretaceous system.

The breadth of the country, underlaid by the Ripley strata, is thus shown to extend from near Fitzsimmons' Landing to near Sandy creek, a direct distance of about forty miles, but this river section is somewhat oblique, and thus, the direct distance, from Fitzsimmons Landing to its margin in Randolph county, is reduced to about thirty miles. In some places, the dip of the formation exceeds fifty or sixty feet per mile, but in such cases the amount is reduced by the return dip, so that probably thirty feet per mile will not be much below the average dip along the river; although it may somewhat reduce the estimated thickness adopted by the joint surveys, which have placed it at 1,080 feet.

Within the limits of Georgia, fossiliferous Ripley beds are found along the Pataula creek. In the gorges of the deeply cut branches, between Pineville and Cusseta, the argillaceous sands were found to contain *Exogyra costata*, and one valve of *Gryphæa mutabilis* was obtained.

Overlying the Ripley series, as just defined, there is a coarse, cohesive sandstone, six feet thick, above which occurs a bed of Ostrea limestone forming an easily traceable feature. The assigned age of the limestone is Lower Eocene. By means of this fossiliferous formation the base of the Eocene has been traced, by the writer, across Georgia to the bluffs along Flint river at Montezuma, thus, the south-

eastern limit of the Cretaceous formations, has been approximately carried seventy-five miles across Georgia, although the surface exposures did not always favor its exploration; being composed of but slightly coherent materials overlaid by superficial loams, which cover alike the higher lands and occupy the more ancient valleys, excavated in the Cretaceous strata, by the streams whose modern phases have not re-excavated the earlier valleys.

GENERAL NOTES ON THE CRETACEOUS SYSTEM.

The southeastern limit of the Cretaceous system has now been found to extend from a point near Sandy creek to Pumpkin Town, in the northern portion of Randolph county, and from there to a point about two miles south of Preston, on Mr. Cole's farm. Thence the line may be drawn to Mr. Carter's farm, at the old post-office of Quebec, on the boundary of Sumter and Schley counties, and from there to the base of the bluffs on the Flint river above Montezuma.

In this preliminary survey, the writer's efforts were devoted to the question of obtaining, provisionally, the approximate distribution and general characteristics of the greater formations in Southwest Georgia, and only incidentally to recording the local variations; hence, no attempt was made to separate the boundary between the Eutaw and Ripley formations, nor to obtain their relative development, which, at best, would be difficult.

From the survey of the Cretaceous system, it is found to have an area, west of the meridian of Knoxville, of two thousand square miles, with an estimated thickness, along the Chattahoochee river, adopted by the joint surveys, of 1,645 feet, if the Tuscaloosa series be included. Eastward of that meridian, the Cretaceous strata are known to still have a great depth, for in the deepest well at Fort Valley, over a thouaand feet of deposits were penetrated. Beneath the superficial covering of loam, etc., probably most of the materials met with were Cretaceous; and, at the depth named, the well was found to be in Cretaceous sands. The records of a shallower well were preserved by Mayor Houser, and are thus given:

1.	Red clay	20 feet
2.	Yellow sand, with occasional layers of coarse white sand with argillaceous binding,	75 feet
3.	White quicksand with a little water	10 feet
4.	Clays of different colors with some sand	85 feet
5.	Quicksand with a little water	10 feet
6.	Laminations of clay and sand	95 feet
7.	Quicksand	20 feet
8.	Clay and sand of vairable colors	170 feet
9.	Quicksand	15 feet
	Total	500 feet

In the deeper well, it was found that a stratum at three hundred feet was water-bearing, but the water did not rise higher than eighteen feet below the surface.

East of the Flint river, the Cretaceous system shrinks to narrow proportions, as the Lower Eocene limestones trend more toward the north, after crossing the Flint river.

The bearing of the rocks upon the topography is illustrated along the Flint valley, in the northern portion of Crawford county, where the river, in the different phases of its history, excavated out of incoherent materials, a valley now represented by swampy lands from two to four miles wide; whilst, further down, this broad character was checked by the more coherent Cretaceous and still harder Tertiary strata.

Upon the more plain like surface of the Cretaceous country, and in the broader depressions, the Cretaceous deposits are capped by loams of the Lafayette series, partly derived from the underlying materials. This source is apparent, for, in the country overlying the more argillaceous Ripley beds, the covering consists of heavier loam or clay, whilst over the more arenaceous beds of the Eutaw and Tuscaloosa series, the superficial covering is more sandy. Many of the Ripley beds are rich in marl and phosphatic material, and, hence, a richer superficial loam is found than where the same is derived from the less calcareous beds farther north. In the deeper valleys of the Cretaceous country, beds of those clays are directly exposed, which are apt to produce bad roads in wet seasons; but this characteristic is confined to a limited area. The relation of the soils is connected with the study of the superficial formation, and will be considered on subsequent pages.

The question of the availability of marls, green sands and phosphatic beds, for local use, must be left for more detailed exploration, because such beds, although of considerable extent along the Chattahoochee, as at Rood's Bend, and near the top of the system, are covered with superficial materials; but they have not been visited in the interior of the country, during the explorations of the few months spent, in the first steps of a geological survey—the determination of geological boundaries and their characteristics.

Many of the beds are characterized as water-bearing, and several artesian wells have been successfully obtained in the upper portion of the Ripley series. But the relationship of these deposits and the domestic water supply will be considered in a subsequent chapter.

In the future study of the historical relations of the members of the Cretaceous system, the following localities are pointed out as the most favorable for obtaining evidence from the fossil remains:

Broken Arrow Bend and shoals, Alabama side; the river bluffs at Fort Mitchell; Chimney Bluff, Georgia (both for fossil plants and shells); Patterson's Bend, below Cottonton; Rood's Upper Bend

above Roanoak; shoals and bluff at Barnett's Landing, Georgia, a few miles below Georgetown; near the mouth of Pataula creek; in the sandstones a short distance above Otho, Alabama, and in the neighboring bluff, over which a high falls cascades, and in the shell marl of the nearly opposite bluff in Georgia. But there are many other localities where Cretaceous fossils are found. Considerable collections have been obtained, but a report upon them cannot be made at this early date of the survey,

Owing to the general scarcity of fossils in the lower members of the Cretaceous formation and absence of marked lithological differences, the specialization of the divisions has been rendered somewhat difficult.

THE PHYSICAL GEOGRAPHY OF THE CRETACEOUS PERIOD.

The physical geography of Georgia during the Cretaceous period presented a marked contrast to that of the preceding eras, when the Archæan rocks formed the rounded shores of the southeastern part of the continent, now represented by Middle Georgia. These lands were low rolling plains, into which the rivers had carved their valleys down to the base level of erosion, and the meteoric agents had moulded the topography into the soft rounded contours. These conditions obtained far southward of the line which now marks their boundary, until the subsidence of the land brought the oceanic waters to the fall line between Columbus and Knoxville, where new shores of the Tuscaloosa formations commenced their growth in the shallow waters. The deposition of the materials appears to have been greatly disturbed by currents, as shown in the cross-bedding of the sands. The conditions were unfavorable to the development of marine life, the remains of which are not found in these accumulations in Georgia. Throughout the Eutaw epoch, similar conditions also prevailed, forming mechanical deposits, still more disturbed by changing currents, which destroyed the continuity of individual strata, and did not favor the assortment of the sediments respectively into beds of clays and sands. But the conditions were somewhat more favorable for the extension of marine life. The work of the currents is also seen in the quantity of the drift wood, which is now found lignitized, and scattered through the series. These varying conditions may probably have been effected to no little extent by the struggle between the Atlantic and the Gulf waves meeting upon the battle ground of Georgia and eastern Alabama; which struggle somewhat ceased in Alabama during the Rotten Limestone epoch, when the deeper and less disturbed waters permitted the formation of heavy calcareous beds, to the depth of one thousand feet, over the subsiding sea floor. But, in Georgia, the lands appear to have been elevated, or only slightly depressed and stationary, so as not to per-

In the deeper well, it was found
was water bearing, but the wate
ter below the surface.

East of the Flint river, the
prospects, as the Lower P
north, after crossing the Flint

CHAPTER IV.

THE CENOZOIC OR TERTIARY GROUP.

THE SUCCESSIVE SYSTEMS.

y or forty years some knowledge of the southern Tertiary s been accumulating, but Dr. E. W. Hilgard has the cre- ing into order such deposits in the Gulf extension of the i valley. To this systematic work are to be added the Dr. E. A. Smith, Mr. L. C. Johnson, and Mr. D. W. Langdon, f the Alabama and United States Geological Surveys. As lopment in Alabama passes, to some extent, into Georgia, nes necessary to take the former as a starting point for the in Georgia. In the brochure of Messrs. E. A. Smith and L. nson, the general development of the Eocene Tertiary, in terior of Alabama, is given as follows in descending order:

System.	Series.		
er Eocene.....	White Limestone.	Salt Mountain.....	150 ft.
		Vicksburg.....	140 ft.
		Jackson.....	60 ft.
ddle Eocene,	Claiborne.....	.....	145 ft.
	Buhrstone (Siliceous).....	.....	300 ft.
wer Eocene.....	Lignitic	Hachetigbee.....	175 ft.
		Bashi.....	85 ft.
		Tuscahoma.....	140 ft.
		Nanafalia	200 ft.
		Matthew's Landing and Naheola	130–150
		Black Bluff.....	100 ft.
		Midway or Clayton.	25 ft.

In the southern part of Georgia, the lower members of the Miocene system succeed the Eocene beds.

Owing to the frequent and strong lithological contrasts in the strata of the Tertiary formations and the outcropping of hard calcareous beds, as characterisitc features, the survey of the geological accumulations has been facilitated. Although the general surface of

the country is overlaid by superficial deposits, yet the harder calcareous beds rise to the surface at numerous points, which would not be marked if the beds were made of incoherent fragmental materials.

The first systematic work of any importance bearing on the Tertiary beds of Georgia was made by Mr. W. D. Langdon when he first surveyed the Chattahoochee river. This river was again resurveyed by the same gentleman, in company with Prof. E. A. Smith, State Geologist of Alabama; Mr. L. C. Johnson, Geologist of the United States Geological Survey, and the writer, as State Geologist of Georgia. The general geological section along the Chattahoochee river is thus seen in descending order:

System.	Series.		Thickness in Feet.
Upper Eocene....	White Limestone.	Vicksburg and Jackson.	310, 500*
Middle Eocene...	Claiborne...	.....	72, 240†
	Buhrstone	.....	164
Lower Eocene.....	Lignitic.....	Hachetigbee.....	10
		Bashi..	44
		Tuscahoma.....	173
		Nanafalia.....	175
		Matthew's Landing and Naheola	Wanting
		Black Bluff	
		Midway or Clayton.....	216(?)

Comparing this last section with the general section in Alabama, it will be seen that there is an important gap in the lower portion of the Eocene system. From more recent information, it is found that the estimate of the White Limestone series was much too small, for from the lithological evidence in the well at Bainbridge, the thickness of the members of the Eocene, from the middle Buhrstone upward to near the top of the White Limestone, ought to be increased from 405 to 750 feet without quite reaching the summit of the series. But part of the difference in estimate may arise from the thickening of the limestone in proceeding eastward; for as already shown, some of the Cretaceous formations are thicker in Georgia than further westward, whilst others are thinner. Other probable changes in thickness, in passing from the west to the east, will be noted.

The estimated thickness of the Eocene in Alabama, as shown from the above table, appears to be 1,690 feet, whilst in Georgia, with the members of the system differently developed, the thickness does not exceed 1,500 feet, by actual estimate; but to this, it may be necessary to add another fifty or one hundred feet before reaching the ex-

* Spencer.
† Spencer.

treme upper limit of the series southeast of Bainbridge. The calcareous development of the Upper Eocene, in Georgia, when compared with its development in Alabama, seems to be the reverse of the conditions of the Cretaceous period, when the calcareous deposits were more largely developed in that State. From the difficulty in identifying individual beds over widely separated areas, it is not always easy to ascertain with accuracy, the dip of the various strata; but from as careful an identification, as possible, of the base of the calcareous members of the Buhrstone, shown along the Chattahoochee and revealed in the artesian wells at Bainbridge and Albany, at their ascertained elevations as to sea level, the writer has trigonometrically determined the mean dip of the Middle and Upper Eocene of South Georgia, at twenty feet per mile, in directions south, thirty degrees east. This calculated dip, if extended to the whole Eocene formation, would reduce the above estimated thickness by an amount from 100 to 200 feet. But this calculated dip cannot be applied to the lower zone of fragmental deposit, which makes up the greater mass of the Lower Eocene rocks along the northern margin, in Southwest Georgia; where the dip of this portion of the formation is taken at twnty-five feet per mile, in the same general direction as the overlying beds. Still, this dip may become exaggerated, which general result is reduced by return dips, thns producing a series of local undulations. Local variations in thickness are more pronounced in deposits of fragmentary materials than in the calcareous matter.

THE EOCENE SYSTEM.

THE LOWER EOCENE OR LIGNITIC SERIES.

Overlying the Cretaceous system along the Chattahoochee river, there are about 600 feet of strata named long ago by Dr. E. W. Hilgard—the Lignitic series, for, in the Gulf States farther west, the formation is characterized by this carbonaceous mineral. Whilst these beds of Lignite become less numerous or almost disappear, in passing eastward, yet portions of the series are found in considerable thickness in Georgia. The greater part of these formations along the Chattahoochee river, is made up of laminated, grey sandy clays, in portions of which the sand predominates and is sometimes cross-bedded. Sometimes the sands are cemented into sandstones by calcareous matter washed out of the marly beds, giving rise to indurated ledges and protruding concretions. The clays are only occasionally tough argillaceous beds, as they frequently contain so much sand as almost constitute beds of quicksand. Such is consequently, the

name applied by artesian well-borers to the materials brought out in process of sinking wells through much of the Lower Eocene formations. Still, there are some harder clay beds. At the base, and near the top of this group of deposits, there are limestones, calcareous sands and marly beds, which serve as land marks.

The Lower Eocene beds form steep bluffs along the rapidly scouring waters of the Chattahoochee river; with the different series having characteristic features; each with its own peculiar *fauna*. which has led to their separation into seven divisions given in the above table.

In Alabama, the lowest or Clayton division, is a calcareous formation of insignificant development, but it reaches considerable proportions in Georgia, and is one of the most conspicuous features of the Lower Eocene system. Its surface has been found eroded, and consequently, there is a gap in the geological succession and the absence of two of the Alabama divisions represented there by 250 feet of sediments. Owing to the impressions upon the topographic features, the lowest or Clayton division, will be considered separately in Georgia. The succeeding divisions will be considered as a unit, except by describing the well-exposed sections along the Chattahoochee river.

MIDWAY (CLAYTON) DIVISION.

Along the Chattahoochee river, the contact beds of the Cretaceous and Eocene systems was not observed, but a bed of coarse-grained, almost conglomoritic incoherent sandstone was taken as the base of the latter. Succeeding this sand, there is a bed of yellowish white siliceous limestone containing a large *Ostrea* (probably *O. alabamensis*), a small *Ostrea*, and several other fossils. It forms steep bluffs, rising from ten to twenty feet above the water, into which numerous caverns recede. This rock commences at a point, about five miles north of Fort Gaines, near the mouth of Sandy creek, and continues for a considerable distance along the river. It is succeeded by white calcareous clayey sand, irregularly indurated, and containing obscure casts of shells. My estimated thickness of this last bed places it at about 135 feet. This indurated bed forms the base of the bluff at Fort Gaines, and weathers into yellow sand. Its surface is eroded, in places, to a depth of ten feet, and is overlaid by succeeding strata. The meaning of this unconformity will be explained later on.

The limestone of this formation is the first of marked lithological difference from the materials of the underlying Cretaceous, though many of the succeeding Eocene beds bear a strong resemblance to those of the older system. Consequently, the limestones form a feat-

ure traceable across the country. They underlie a belt of country, about five miles wide, the surface of which, though deeply covered with superficial deposits, is somewhat characterized by lime-sinks, often forming ponds.

From the Chattahoochee river, trending northeastward, the limestones occasionally penetrate through the superficial accumulations and produce bluffs rising to 25 feet or more above adjacent streams, and along the Flint river form the lower portion of a much higher escarpment. This mostly buried escarpment faces the northwestward. In the northern part of Randolph county, it forms the exposures at Greer's Cave, near Pumpkin Town, where the fossiliferous limestones are about 25 feet thick and form a bluff along a little branch. This locality has a wide local reputation on account of the presence of two caves of considerable size. South of Greer's Mansion (Pumpkin Town) the rocks are crossed by the Cuthbert road.

The individual beds of Clayton limestone reach as much as six feet in thickness and are compact and hard. Other layers, especially near the summit, are incoherent marly beds, full of fossils, especially a small *Ostrea*, *Pecten*, etc. The same species of *Ostrea*, characteristic of this limestone, is also found in northern Randolph. These beds of calcareous material reach a thickness of 30 feet. The elevation of the formation at this point is about 150 feet above that along the Chattahoochee river, and, hence, if for no other reason, the northern frontier would have a northeastward trend.

On Mr. G. W. Cole's farm, about two miles south of Preston, the Clayton limestone forms a bluff rising about 25 feet above an adjacent branch. From this locality characteristic fossils were obtained.

The northern boundary of the formation continues northeastward and appears on the farm of Mr. J. T. Carter, near the old post-office of Quebec, on the southern boundary of Schley county, where an exceptionally rich accumulation of fossils occurs. In the neighboring wash-out, the underlying coarse conglomeritic sand was found beneath the Oyster zone.

From this locality the formation trends northeastward to the Flint river, generally with bluffs up on the western side, and reappears on the eastern in the bluffs north of Montezuma. On the western side of the river, at Montezuma wagon bridge, there is a flinty sandstone which belongs to the base. In the limestones at Montezuma, there are many large pockets almost entirely made up of large Ostrea shells, the fillings of which have sometimes been weathered out, leaving the rock full of cavities. One of the upper layers of this massive limestone is composed of incoherent masses of shells of several species, amongst which a small decomposed Ostrea predominates. The whole forms a valuable friable marl. The calcereous beds rise to about forty feet above the river, in the bluff, which is best exposed

the Georgia side of the river. Here were found quantities of *Exogyra costata* and the large shells of *Gryphœa mutabilis*. Below this point follows a succession of gray yellow sands, occasionally calcareous or argillaceous, and with sometimes indurated layers. Some of the beds contain Ripley shells and lignitized wood. Such were found in the argillaceous sands at the mouth of Pataula creek. Farther down the river, there is a ledge of sand, hardened into sandstone and containing *Exogyra costata* and *Echinoids*. This last bed is seen at the surface, for a considerable distance, owing to the return dips. The Echinoids are most abundant at the mouth of a small branch cascading over the sandstone, a short distance above Otho, Alabama. Just below the last named exposure, upon the Alabama side, at a point where the stream falls over a high bluff, there is a dark sandy micaceous and bituminous clay, in which friable fossils are delicately preserved, amongst which was a beautiful specimen of *Ammonites*. This bed is overlaid by a stratum of shell marl, containing numerous fossils, which is best seen upon the Georgia side, nearly opposite to this fall. The clayey sands containing *Exogyra* were found for two or three miles below Otho. Over these beds succeed coarse conglomerate, followed by a few feet of massive blue clay, which, at a point a little above Sandy Creek, Clay county, has been accepted by the joint surveys, as a summit of the Ripley series, and indeed, of the Cretaceous system.

The breadth of the country, underlaid by the Ripley strata, is thus shown to extend from near Fitzsimmons' Landing to near Sandy creek, a direct distance of about forty miles, but this river section is somewhat oblique, and thus, the direct distance, from Fitzsimmons Landing to its margin in Randolph county, is reduced to about thirty miles. In some places, the dip of the formation exceeds fifty or sixty feet per mile, but in such cases the amount is reduced by the return dip, so that probably thirty feet per mile will not be much below the average dip along the river; although it may somewhat reduce the estimated thickness adopted by the joint surveys, which have placed it at 1,080 feet.

Within the limits of Georgia, fossiliferous Ripley beds are found along the Pataula creek. In the gorges of the deeply cut branches, between Pineville and Cusseta, the argillaceous sands were found to contain *Exogyra costata*, and one valve of *Gryphæa mutabilis* was obtained.

Overlying the Ripley series, as just defined, there is a coarse, cohesive sandstone, six feet thick, above which occurs a bed of Ostrea limestone forming an easily traceable feature. The assigned age of the limestone is Lower Eocene. By means of this fossiliferous formation the base of the Eocene has been traced, by the writer, across Georgia to the bluffs along Flint river at Montezuma, thus, the south-

eastern limit of the Cretaceous formations, has been approximately carried seventy-five miles across Georgia, although the surface exposures did not always favor its exploration; being composed of but slightly coherent materials overlaid by superficial loams, which cover alike the higher lands and occupy the more ancient valleys, excavated in the Cretaceous strata, by the streams whose modern phases have not re-excavated the earlier valleys.

GENERAL NOTES ON THE CRETACEOUS SYSTEM.

The southeastern limit of the Cretaceous system has now been found to extend from a point near Sandy creek to Pumpkin Town, in the northern portion of Randolph county, and from there to a point about two miles south of Preston, on Mr. Cole's farm. Thence the line may be drawn to Mr. Carter's farm, at the old post-office of Quebec, on the boundary of Sumter and Schley counties, and from there to the base of the bluffs on the Flint river above Montezuma.

In this preliminary survey, the writer's efforts were devoted to the question of obtaining, provisionally, the approximate distribution and general characteristics of the greater formations in Southwest Georgia, and only incidentally to recording the local variations; hence, no attempt was made to separate the boundary between the Eutaw and Ripley formations, nor to obtain their relative development, which, at best, would be difficult.

From the survey of the Cretaceous system, it is found to have an area, west of the meridian of Knoxville, of two thousand square miles, with an estimated thickness, along the Chattahoochee river, adopted by the joint surveys, of 1,645 feet, if the Tuscaloosa series be included. Eastward of that meridian, the Cretaceous strata are known to still have a great depth, for in the deepest well at Fort Valley, over a thouaand feet of deposits were penetrated. Beneath the superficial covering of loam, etc., probably most of the materials met with were Cretaceous; and, at the depth named, the well was found to be in Cretaceous sands. The records of a shallower well were preserved by Mayor Houser, and are thus given:

1. Red clay	20 feet
2. Yellow sand, with occasional layers of coarse white sand with argillaceous binding,	75 feet
3. White quicksand with a little water	10 feet
4. Clays of different colors with some sand	85 feet
5. Quicksand with a little water	10 feet
6. Laminations of clay and sand	95 feet
7. Quicksand	20 feet
8. Clay and sand of vairable colors	170 feet
9. Quicksand	15 feet
Total	500 feet

Just below the mouth of Camper creek, the following section appears:

1. The red or orange loam, passing into .....8 feet.
2. Layer of quartz pebbles on an unconformable bed.....4 feet.
3. Gray and yellow laminated sands..... 8 feet.
4. Yellow laminated sandy clay.....12 feet.

Only the lower twenty feet of this section belong to Eocene deposits. Further down the same bluff, the orange loam has a thickness of twenty feet and rests unconformably upon a laminated blue clay, under which is a bed of sand. At a point about nine miles, direct (18 miles by water), below the Oglethorpe-Montezuma railway bridge, at the bend where a steamer was sunk, there is a bluff on the western side of the bend, showing an excellent section.

1. Orange loam.....2 to 6 feet.
2. Gray, sandy clay, surface and base irregular.....6 to 1 feet.
3. White sand, undulating.....2 to 6 feet.
4. Gray clayey sand.....3 feet.
5. Dark purple laminated sand, exposed.....2 feet.

In this section, only the three lower members belong with certainty to the Lower Eocene series.

At the mouth of Mountain (?) creek on the western side of the Flint river, there is a conspicuous bluff showing exposures of Eocene sediment.

1. Orange loam (superficial).....variable.
2. Gray clay..... 6 feet.
3. Dark, purplish, laminated, sandy clay .....12 feet.
4. White clay, exposed..... 10 feet.

All these beds dip at from 50 to 80 feet per mile towards the southeast. This is the last exposure of laminated mechanical deposits belonging to the Lower Eocene exposed along the Flint river. The next bluffs are those of limestone forming the conspicuous feature above Danville.

Thus, it will be seen that between the base of the Eocene formation, at Montezuma, and the limestones belonging to the middle Eocene at Danville, the rarity of exposures of Eocene formations renders the determination of a continuous section of those deposits impossible. Yet, at extreme low water, it is possible or even prob-

able, that more exposures might be met with. Fossils were not obtained, and therefore, in the sections given, the exact division to which each of them belongs has not been determined. But the more southern section above given has a general resemblance to the Bashi series, and in location it was found where that formation might be looked for, and consequently, the locality is placed as the southern limit of the Lower Eocene.

Along the road, between Oglethorpe and Americus, where it crosses Sweetwater valley, a whitish coarse sand, cemented with clay, occurs. This, too, lies near the upper portion of the Lower Eocene. Lower Eocene sands are also found at the base of the remarkable bluff, at Bluffton, in Clay county. About two miles southwest of Pumpkin Town, in a washout beneath a heavy covering of red loam, there is found a coarse white argillaceous sand and in the bottom of the ravine a yellowish white pipe clay. About five miles north of Cuthbert, on the road to Pumpkin Town, there is a white clay beneath the orange loam covering; this probably belongs to the upper Midway or Clayton division.

Other evidences of the lower Eocene are found at several points revealed by artesian wells. These will be considered later; but especial attention is called to the section shown in the artesian well at Americus.

The total breadth of the Lower Eocene system, along the Flint river, does not exceed eleven or twelve miles, but in the western part of the State it has a width of fourteen miles, and in the diagonal section, along the Chattahoochee river, the direct distance is about seventeen miles. As may be seen from the table (page 42), the total thickness of the Lignitic series along the Chattahoochee river is taken at 618 feet, which is probably the maximum in western Georgia, as the belt appears to diminish towards the northeast. As has been already noted, there is a hiatus in the Lignitic series along the Chattahoochee river. One of the absent divisions is characterized farther west by phosphatic beds. The physical history of the gap will be noted at the close of the chapter on the Eocene system. The Lower Eocene has yielded valuable materials for the superficial deposits which form the soils of this portion of Georgia. The sandy beds form some of the most important water-bearing formations of the south. At Cuthbert, the soft Lower Eocene (Midway) limestone is quarried for building purposes with good results.

MIDDLE EOCENE SERIES.

BUHRSTONE DIVISION.

This division of the Middle Eocene system, in the Gulf States, was founded on lithological grounds, being distinguished as the siliceous portion, whilst the overlying Claiborne represents the calcareous beds

of the series. These different formations represent epochs of very dissimilar conditions. But upon palæontological evidence, there is no sufficient reason for their separation, as shown by Dr. Hilgard and Dr. Smith. The lithological name, unlike those of other members of the Eocene system of geographic origin based upon typical localities, has objections, as it raises a popular idea of a succession of a certain economic mineral which is not confined to a single horizon; and only to a limited extent do such hard quartzitic, flinty, porous rocks contribute to the mass. The characteristic materials of this division, as given by Messrs. Smith and Johnson, consist of gray or light argillaceous sandstones, often glauconitic, with numerous concretions of pure clay, traversed by streaks of oxide of iron; indurated white clay, light and easily broken; hard, coarse-grained glauconitic sandstone; yellowish and streaked hard siliceous and aluminous sandstone; and white siliceous, almost quartzitic rock associated with the hard siliceous sandstone. These more flinty deposits, similar to buhrstone, occur near the base of the series. The most abundant materials are the indurated clays and argillaceous sandstones.

Along the Chattahoochee river, there is a succession of formations which are correlated with the Buhrstone of Alabama. These consist of a similar development of white fossiliferous sand, succeeded by heavy developments (from 40 to 50 feet each) of coarse, cream colored aluminous rocks, sandy in places, and light green sand with small *Ostrea sellæformis;* and at the top of the division, cream colored siliceous slightly calcareous rocks in hard and soft layers, forming projecting ledges, seldom more than two feet thick. At an angle in the river, about four miles due south of Yantayabba creek, there is a ledge on the west side, rich in *Ostrea divaricatia*, *Anomia*, etc.

The estimated thickness of this deposit is 164 feet, and it extends from the mouth of the Yantayabba to the island at the mouth of Omussee creek, near Columbia, Alabama—a direct distance of about eight miles. This formation was crossed at only one or two points, except along the river. No distinctive features were seen along the Flint river. The hills above Americus appear to be capped by the lower members of the division, which have furnished the fossiliferous fragments or blocks, to the overlying. superficial materials. In the railway cut, about three miles from Americus, on the road to Preston, there is an excellent exposure of a white rock having the appearance of decayed limestone with resulting residuary sandy clays, charged with great irregular boulders of fossiliferous and porous hard quartzose rock, or buhrstone rock. The fossils have not yet been examined, but from the lithological character and the geographical position, they are here placed as belonging to this division of the Middle Eocene. The surface of the water-works' wells, at Americus, is over 100 feet below the above described rocks, capping the adjacent hills and covered with rocks of the Buhrstone division; hence, the materials brought to light in the borings belong to the

Lower Eocene. The boundary line between the Buhrstone and the overlying Claiborne has not been determined across Southwestern Georgia, but it is shown in the bluffs along the Flint river, above Danville.

THE CLAIBORNE DIVISION.

This Eocene series, so well known on account of its rich fauna, forms a feature along the Chattahoochee river, but differs somewhat in its development in Alabama and Georgia; in one particular, the the more highly fossiliferous upper portion has not been found along the Chattahoochee. In Alabama, this upper portion consists of ferruginous, or where not weathered, somewhat glauconitic sand. Beneath the Upper Claiborne division in Alabama, there are some sixty feet of calcareous clays and sands, characterized by great quantities of *Ostrea sellæformis* which strongly marks this horizon. Below this horizon there are fifty more feet of sandy and clayey beds, which are often glauconitic.

Along the Chattahoochee; the Middle Claiborne beds are those most wide-spread, and are also those principally developed. Here, they are composed of alternate beds of indurated and soft marl, and, of white and yellowish-white sandy limestone, the softer strata of which are rather aluminous. The hardest strata weather out into "root-like shapes," whilst the softer recede beneath the overhanging ledges, by which the dip of the strata is rendered conspicuous. The dip often reaches several degrees, but, in returning, the beds are frequently brought again to the surface, thus reducing the general average and spreading the limestones over a broad belt of country. The projecting ledges extend throughout the formation. The *Ostrea sellæformis* is most favorably preserved in the hard ledges at the junction with the softer. Abundance of small shells of the same species occur in many localities, whilst the larger varieties are more commonly found in pockets. The calcareous bluffs of the Claiborne series extend from the island at the mouth of the Omussee (near Columbia), the surface of which is covered by a bed, rich in large varieties of the characteristic shell—to a point opposite and below Gordon, Ala., and there passes beneath the next formation, which appears at the Midland Railway bridge. Thus the formation has a breadth of about twelve miles, with a calculated thickness of about 240 feet, though this is greatly in excess of Mr. Langdon's estimate, which has been generally adopted by joint surveys. For, at that time, the data from the wells in Georgia had not been collected.

Along the Flint river, the Claiborne beds are well marked; commencing in the bluff just above the old Danville ferry. This bluff is over half a mile long and is composed of alternate layers of hard and soft sandy limestones, with beds as much as four feet thick, the softer beds having more marly and clayey appearance. The rock

is of a greenish or yellowish white color; its surface weathers into somewhat rough, but hardly jagged forms, which are so characteristic of certain beds of an overlying cherty formation. These Claiborne beds are well characterized by *Ostrea sellæformis*, which are most abundant at the base of and in the harder ledges. In these bluffs, the limestones rise to somewhat over twenty feet above the water, and they are capped by an equal thickness of superficial sands and loams.

Above and below the mouth of Ebenezer creek, upon the left bank, excellent exposures occur in steep bluffs rising to fifteen or twenty feet above high water. Here, the beds appear for considerable distances as quite horizontal, but again suddenly bend down at steep angles, which are followed by a return dip, thus producing undulations. The hard ledges stand out in bold relief, and the softer have a clay-like appearance. In some of the beds, these harder layers form the larger proportions of the mass; in others but a small proportion. The softer beds appear at Shell Bluff and again at Warwick. The last important exposures of these rocks were seen in the bluff on the right bank of the river upon the southern side of the Great Bend, a short distance above the new railway bridge, between Albany and Cordele. The bluff rises twenty feet above high water, and extends for nearly two miles. The texture of the different layers is less varied than in the lower portion of the series, but the face is largely worn into small root-like protuberances. Occasional pronounced rostra or platforms stand out in graceful projection over the waters. These bluffs are carved into recesses by many springs flowing through subterranean passes, which occasionally open beneath the surface of the river, discharging pools of clear water in the otherwise muddy current. The locality is taken as the southern limit of the Claiborne series, which limit may have to be somewhat modified by the palæontological evidences. Still, about four miles above this point, on the top of the bluffs upon the eastern side of the river, there are some flinty, fossiliferous rocks belonging to a higher formation. These, although farther north along the river, are also farther eastward, and probably indicate an irregular outline for the boundary of the formation. Accepting this provisional boundary, its breadth reaches about twenty miles in the meridional direction, or from twelve to fourteen miles directly across the zone.

Along the Muckalee and Kinchafoonee creeks, bluffs of Claiborne limestones and marls appear, but these have not been sufficiently explored. At many points throughout the Claiborne belt, the limestones appear near the surface, as for instance, near Leary's, at Morgan, in the bed of the creek at the Corday mill, (which is near the northern limit) and other places; but future investigations may somewhat vary the assigned boundary of the Claiborne zone between the

exposures on the Chattahoochee and the Flint, yet the width, as indicated will probably be found to extend across the western part of the State.

Several wells have been bored through the Middle Eocene formation, and the information derived therefrom has been used in constructing the provisional map. If the lithological identifications at Albany be correctly made, the thickness of the formation will not materially vary from that assumed from the calculated dip of the formation in Southwest Georgia, or a thickness of two hundred and forty feet.

UPPER EOCENE SERIES.

WHITE LIMESTONE SERIES.

Under this title, all the remaining Eocene formations of Georgia are included. These consist of beds of limestones, varying somewhat in character and in fauna; but the characteristics, so far determined, do not point to sufficient grounds for subdivision. This grouping in Georgia is made to include the long known Jackson and Vickburg divisions of the more western Gulf States.

The rocks of the lower part of the series are light colored, argillaceous limestones, with some layers of purer calcareous material. This horizon is characterized by the sea urchins—*Scutella lyelli*, and a smaller species, and *Pecten perplanus*, etc. This section has an estimated thickness of twenty-five feet, and occurs at the Alabama Midland Railway bridge, over the Chattahoochee river, in the southern part of Early county. This is the horizon of the *Zeuglodon cetoides*, a sea monster, seventy feet long, in structure between a whale and a seal.

The middle portion of the White Limestone is largely a hard crystalline and locally siliceous limestone, weathering into irregular vesicular masses, left from the solution of the calcareous matter of the fossiliferous and highly siliceous portions of the limestone. Some portions of the White Limestone are soft with an earthy appearance, and can be used for building purposes, hardening on exposure. This division of the White Limestone is especially characterized by *Orbitoides mantelli*, which often fills the mass of rock with their disks; hence, the name of Orbitoidal limestones.

Along the Chattahoochee river, this limestone continues from the Midland Railway bridge to Mariam Landing, in Decatur county; south of which locality the Chattahoochee banks are unfavorable for their exposure. But a few miles eastward, these rocks appear in a a bluff at the bend of the Flint river, near the mouth of Fowlstown swamp, which exposures are also the most southern seen along this river.

The Flint river enters the zone of the White Limestone near the mouth of Jones' creek, and continues therein to the point just referred to, six miles southwest of Bainbridge.

Near the mouth of Jones' creek and a little below, at Cotton Bluff, in Lee county, boulders of hard silicified vesicular rock rise out of the soft, earthy, rotten looking limestone. The vesicles have the appearance of cavities formerly occupied by sponges, from one to two inches in diameter. At the latter place, numerous fucoidal and coprolitic masses, an inch in diameter are weathered out; these may be phosphatic.

At the mouth of Pine Wood's creek, the earthy limestone, containing a few fossils (polyzoa and small corals) form a bar extending into the river. At the rapids, about five miles, in a direct line, northeast of Albany, on the western side of the river, there are huge boulders of siliceous rock resting on the chalky limestone. From the mouth of Kinchafoonee creek, the vesicular limestones form the surface of rock exposure. At Albany, we find the same superficial rock associated with the more earthy. About two miles below Albany, there is the first locality seen, where the limestones form both bluffs of the river, showing the reducing of the base-level of erosion. Opposite the mouth of Dry creek, is Goat Island, beyond which there is a huge pile of scoriaceous fossiliferous boulders,—the bluffs whence they came having been otherwise entirely removed by erosion. This condition is represented in a photograph. Such boulder heaps, often forming islands, are characteristic of many points above the mouth of the Ichawaynochaway (one of which near this was photographed). From this point down to the mouth of Fowltown Swamp, such superficial vesicular masses, as have been described, are occasionally found upon the surface of the limestones; having originated from the solution of the calcareous matter of the siliceous limestones.

Other exposures of the White Limestones have been examined in Decatur county, notably near Blowing cave, where a stream cascades into a bowl 60 feet in diameter and 40 or 50 feet deep, with vertical walls of the White Limestone of the more earthy type. A section of about 90 feet of these rocks is exposed at Forest Falls, a lime-sink already noted on page 20 of this report. The rock throughout is largely of the earthy type without any important development of the silicified pockets so often shown along the Flint river. In this chalky limestone, fossils are not well preserved, but *Orbitoides* was found.

At Bainbridge, a well was sunk through this formation, the record of which is given me in descending order:

SECTION.

1. Sand and clayey sand.....75 feet.
2. Limestone; the upper 200 feet the softer; no clayey layers 700 feet.
3. Soft limestone.....50 feet.
4. Quicksand to bottom of well.....75 feet.

A second well was sunk, within three feet of the first, which penetrated, below the limestone, to a depth of 425 feet in quicksand. Shark's teeth, lignite and pyrite concretions came from some of the layers of the sand. Several cavities in the limestones were passed through; the deepest being three feet.

The thickness of the White Limestone formation is here placed at 500 feet. From 700 feet of harder limestones shown in the Bainbridge well. 240 feet have been deducted as belonging to the Claiborne series; corresponding to the thickness derived from the mean dip of the Middle and Upper Eocene in Southwest Georgia. To the remaining 450 feet, assumed as the White Limestone, 40 feet more have been added, for Bainbridge is a short distance north of the boundary of the formation, as it crosses Decatur county. This thickness is in harmony with the average dip of the system. The whole belt has a breadth of 25 to 28 miles.

GENERAL NOTES UPON THE MIDDLE AND UPPER EOCENE SERIES.

The rivers and streams which flow through the country, are more or less characterized by bold bluffs. Over this country, there is also an extensive development of lime-sinks, often occupied by swamps or lakes, as the outlets to these depressions often become filled. Many of these lakes are evenescent, the waters occasionally sweeping away the materials damming the subterranean outlets. Another striking physical characteristic of this country is the absence of the numerous small streams which appear elsewhere in Southwest Georgia. This arises from the drainage of the region by subterranean outlets that, in part, find their way to the larger rivers.

The country underlaid by the Buhrstone formation is often moulded into prominent hills and valleys. That above the Claiborne becomes flatter but yet rolling; but the country overlying the White Limestone series is remarkably level.

The effect of the limestone upon the soil will be considered later. Some of the more marly beds will be found to be of value to agriculturists. The purer beds of limestone will prove useful in building purposes. But the full local value of these materials cannot be announced, as the country has been surveyed only along a few lines, in order to approximately determine the boundaries of the different zones; and local conditions are constantly varying their availability.

RICH HILL.

Rich Hill, six miles southeast of Knoxville, belongs to an outlying district not yet geologically correlated with the sections in Southwest Georgia, but as it contains some Eocene rocks, a record of it is here appended, as shown in the following section:

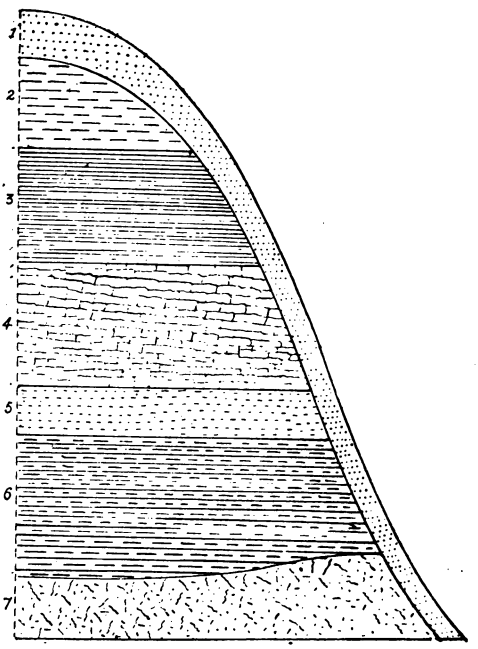


FIGURE 6.

1. Orange or red loam unconformable, on.....10 feet.
2. Laminated colored sands with clay partings.....20 feet.
3. Grayish white compact clay.....25 feet.
4. Sandy limestones; the lower beds separated by beds of red sand; contains echini, sharks' teeth, etc.....25 feet.
5. Light colored gray sand.....10 feet.
6. Pure white sand.....30 feet.
7. White clay with surface eroded.....10–15 feet.

CHAPTER V.

THE MIOCENE SYSTEM.

Along the Chattahoochee river, succeeding the White Limestone, there is a series of argillaceous, sandy limestone forming the "Chattahoochee series," thus named by Mr. Langdon. Succeeding this formation is the Alum Bluff series, a highly fossiliferous Middle Miocene sand. These formations extend some distance into Florida. The Chattahoochee series, however, underlies a considerable area of the southwestern portion of Decatur county. It is well developed in the extreme southwestern corner. On the road from the steamboat landing, leading to the village of Chattahoochee, 70 feet of this whitish soft, highly argillaceous, sandy limestone, are shown along the lower portion of the bluff, which rises into the terrace 175 feet above the river. This formation probably extends much higher in the terrace, but it is concealed by the mantle of orange loam. This deposit, when wet, becomes plastic, but when dry it crumbles more or less. The formation is thus described by its author: "Argillaceous and sandy limestone, alternating with strata of purer character; it contains a *Pecten*, an *Ostrea* very closely related to our *Virginica*." We also found the remains of *Decapods*, and Mr. Johnson and myself found fragments of vertebrate remains. The railway cuts adjacent to Chattahoochee afford several good exposures.

A mile west of Recovery Station, the same deposits are found, with the lower portions consisting of the softer sandy marl, and the upper of more solid limestone. At this point, there are some picturesque sinks. Overlying these deposits, there is a whitish, coarse, clayey sand of which only the upper ten feet are exposed. This deposit is correlated with the limestones as part of the Chattahoochee series. These white clayey sands are well exposed at the base of the railway cut on the road to Bainbridge, about one mile west of Climax. This section will be given in a succeeding chapter.

Similar white sandy clays and clayey sands extend to eastward of the meridian of Cairo, beneath a belt of 15 miles or more in width. They were seen at several localities between Mr. R. A. Connell's farm, four miles northeast of Whigham, and the mouth of the Attapulgus creek, in one direction; and near the mouth of Tired creek in another. These materials are popularly called pipe clay, some layers having an excess of sand, others forming a plastic clay. Numerous

wells are sunk into these deposits, which will not stand as a firm wall, like the overlying orange loam. The wells require to be curbed. Near the Attapulgus creek, just north of the boundary line of Florida, on the farm of Hon. W. E. Smith, the more calcareous beds of the Chattahoochee series were seen along some of the branches. Overlying these deposits, as shown in the railway cuts near Whigham, darker colored Tertiary sands and clays were seen; but the subdivision belt to which they belong has not been determined.

On Ponto creek and adjacent streams, near the Floridian boundary, westward of the Ochlockonee river, soft marly limestones were found, having a depth of more than 25 feet. These resemble in appearance those at Recovery. A medium sized *Ostrea*, *Pecten* and other fossils were found in them. They give rise to lime-sinks along the State boundary. Passing northward from Ponto creek, some six miles from Florida, on the Cairo road and adjacent to Tired creek, extensive exposures occur where a fossiliferous silicified limestone forms a prominent feature. Fragments of this stone also occur in the superficial materials of the district, thus showing that it is a subjacent formation. About four miles southeast of Cairo, on Mr. McCrone's farm, and in the valley of Provor's creek, similar silicified rocks are found. These were formerly quarried for millstones. This belt trends northeastward, towards Ochlokonee post-office. Eastward of this zone, at Thomasville, there are 162 feet of clays and sands revealed in the artesian well; only the upper portion of these belongs to the superficial covering of the country. A few miles eastward of Thomasville, there is another belt of fossiliferous limestone; these rocks are well shown in the sink on Mr. Braswell's farm about six miles southeast of Thomasville. Rocks are seen at several points, as at the phosphate beds west of Boston; and several miles farther northwestward of Patten post-office. This zone is characterized by lime sinks such as those southwest of Boston and those of Dry and Round Lakes north of Boston.

Eastward of this belt, there is another Miocene series of sandy clays containing poorly preserved remains of a large oyster. These are seen about four miles southeast of Boston.

Farther eastward, or southeastward, there is a zone, near the Piscola creek, characterized by a brecciated siliceous rock, with opal like characters, and slightly phosphatic. This is seen on the farm of Mr. Cutler, and is said to extend northeastward of Quitman.

Beneath the superficial covering of this country, the boundary lines of the different zones of these Miocene rocks have not yet been determined.

In this preliminary report, no complete effort has been made to work out their full relations, by the fossils. But from the Miocene beds along the Chattahoochee river, and from the Miocene character of the

fossils along the phosphatic belt east of Thomasville, determined for me by Dr. W. H. Dall, and from their stratigraphic relations, it appears that the greater portion of southern Decatur, and all of Thomas county, are underlaid by members of the Miocene system. The thickness is not determinable as yet. It exceeds 400 feet, and will probably be found very much greater, when the whole region is investigated, unless the Miocene deposits shall have been found repeated by return dips, or by the presence of islands within their belt.

GENERAL NOTES ON THE MIOCENE SYSTEM.

The country underlaid by these deposits in Decatur and Thomas counties is generally a high, rolling plain into which the streams are carved to a limited extent. A zone of lime-sinks crosses the Miocene belt in the eastern part of Thomas county.

There is a marked difference in the soil, although less so in appearance, between this region and that of the White Limestone to the north. The phosphate beds are related to the rocks of this formation, but will form a separate subject; as also the water-supply, and the favorable climatic character of this portion of Georgia.

THE PHYSICAL GEOGRAPHY OF THE CENOZOIC PERIOD.

At the close of the Cretaceous period, the muddy shallow waters were replaced by a clearer and somewhat deeper sea, favorable for the growth of organic life, which resulted in the formation of the calcareous rocks of the Midway epoch; later, there was a re-emergence, and finally an elevation of the land of Southwest Georgia, although not of Central Alabama, where the Midway subsidence had not reached the proportions shown in Georgia. This epoch of elevated land was marked by rivers, the carving of the newly elevated plains, and the forming of valleys. This condition prevailed through two short epochs, recorded in Central Alabama by the formation of a few hundred feet of sands and sandy clay. The evidence of this elevation is preserved at Fort Gaines, where there is an unconformity in the beds (first discovered by Mr. Langdon), and the absence of the two divisions referred to. The remaining portion of the early Eocene period was characterized by shallow seas and swamps, wherein lignite was formed. But these lignite-producing swamps prevailed to a greater extent in the western Gulf States than in the eastern, and diminished to small proportions in Southwest Georgia, where they appear to have been replaced by the shallow seas building up the shores of Georgia.

The middle and later Eocene period was characterized by deeper

waters than the Lower Eocene epoch, and more favorable conditions for the development of nearly eight hundred feet of limestone.

The Miocene period commenced with a shallowing of the waters marked by more sandy coast lines supporting an extensive marine fauna. But as far as our scanty information goes, the period was marked by one of terrestrial oscillations in Southwest Georgia.

Eocene formations reappear in Northern Florida, where it is probable that during the Miocene period, the older portions of that State formed an island (as first suggested by Mr. L. C. Johnson) between which and the mainland of Georgia, there was a broad strait being slowly filled up with deposits of Miocene age, now underlying portions of Decatur and Thomas counties. But the end of the Miocene period is not recorded in Southwest Georgia.

CHAPTER VI.

PLIOCENE AND PLEISTOCENE SYSTEMS.

COLUMBIA SERIES.

LAFAYETTE SERIES.

Spreading out as mantles over the whole Southwest Georgia, there are deposits of orange or red sandy clays or loams, massive and laminated sands, with local gravel deposits, and occasional lighter colored clays. Whilst the older formations succeed each other and underlie successive zones or belts of country, these superficial deposits cover all of the older strata from the Miocene deposits, on the Floridian boundary, to the base of the Cretaceous, and, indeed, overlap the edge of the crystaline rocks along the fall line between Columbus and Knoxville. The range of altitude throughout which these accumulations extend reaches from elevations of eight hundred feet above the sea, down to, and occupying, the lowest valleys at less than one hundred feet, in the section of the State under consideration.

Two distinct formations are recognizable in these superficial accumulations. To Prof. E. W. Hilgard belongs the honor of commencing their study, long ago, in Mississippi. Equal credit is due to Mr. W. J. McGee, who has carried his investigations from the Potomac river to the Mississippi, and discovered the relationship between these deposits in the Atlantic States with those in the Gulf region. For the lower series, the terms *Orange Sand* (Safford and Hilgard), and the *Appomattox* (McGee), became incorporated in geological literature. The results of recent conferences have led to the adoption of Prof. Hilgard's name of Lafayette (from a typical Mississippi locality), and the final abandonment of both the other terms. The upper series is named the Columbia (from the typical locality in the District of Columbia), by Mr. McGee, who has carried his investigations over a wide territory. This explanation is given here, because the nomenclature, involving changes, has only been recently settled.

These accumulations form to-day some of the most interesting series of geological records in the Southern States. They constitute the soils of Southwest Georgia. Nor are these deposits simple, for they rest on the old sculptured surfaces of the land, occupying older valleys excavated alike out of the Cretaceous, Eocene and Miocene formations, and often entirely obliterate the ancient

smaller water-courses. The lower of these materials have their own surfaces eroded and are covered by the higher accumulations of the series. These materials, in Georgia, have been studied in part by Professor J. E. Willett, Mr. W. J. McGee and the writer, as shown in their published papers, but the history is not as yet wholly explained, for the records are incomplete.

The superficial deposits in Southern Georgia, are quite distinct in character from the underlying Tertiary and Cretaceous beds, and mark distinct physical conditions of accumulations, which were similar in both the Lafayette and Columbia epochs.

The data for the determination of the exact age of the Lafayette series is not known. It unconformably overlies the Middle Miocene formations, and again it unconformably underlies the Columbia beds, which are assigned to the Pleistocene periods. The Columbia series is correlated with the lowest Pleistocene deposits of the north, by Mr. W. J. McGee, who accordingly assigns the underlying Lafayette to some epoch of the Pliocene or the later Miocene period. Upon the present evidence, I am unprepared to accept this conclusion; because of the close geological resemblance of the Lafayette series to the Columbia, and its dissimilarity to the underlying Tertiary formations; and because high continental elevations generally characterized the Pliocene period. In harmony with Mr. McGee's conclusions as to the identity of the Columbia accumulations, with those of the lowest known drift of the North, it may be hypothecated that the Pleistocene period commenced earlier in the South than in the North, leaving its records in the Lafayette deposits. This suggestion would conform to the idea of Dr. G. M. Dawson, that there were alternating continental conditions between the Pacific coast regions and the northwestern plains, during the Pleistocene period.

Provisionally, I place the Lafayette and Columbia series together, and give the following local descriptions without regard to their somewhat unsettled age, and their local differentation. The Columbia series shows also two divisions, the latter confined to the valleys.

THE LAFAYETTE AND COLUMBIA MANTLES IN THE FINT VALLEY.

At Fair Play Hill, two and one-half miles north of Knoxville, capping the ridge, there is a deep red sandy loam, containing small rounded pebbles, of which a thickness of ten feet is exposed. This point is one of interest, as being at or near the most northern limit of the belt, and at an elevation of about eight hundred feet above the sea. At Rich Hill (see figure 6 on page 56), about six miles southeast of Knoxville, the same red loam forms a capping at an elevation of 835 (?) feet; and near by, gravel is seen on the hills at fifty feet below. At both these localities, the loam forms a capping for both the

surface and the sides of the hills, where the underlying formations were incised by former eroding streams. This condition is common to the formation, as it forms a sheet alike over the ancient hills and greater valleys. The base of this loam, especialy in the vicinity of the greater rivers, passes into a well marked bed of rounded quartz gravel, sometimes three inches in length. Such gravel is seen upon the hills between Knoxville and the Flint river, at elevations of 130 feet above its modern high water. South of Knoxville the red loamy surface is replaced by a belt of loose gray sand.

The country south of this point is, commonly speaking, a high plain somewhat incised by streams. The surface is generally composed of the orange loam, which varies in thickness from zero to 20 feet, as shown in the railroad cuts south of Gaillard's. (See figs. 2, 3, 4, page 30.) At Fort Valley, this red loam or clay reaches a depth of 2 feet, as shown in the artesian well. About three miles south of Fort Valley, there is an excellent exposure in the railroad cut on the road to Americus.

1. Deep colored red loam or hard sandy clay, with rounded gravel in the lower two feet, resting upon an eroded surface...6–10 feet.
2. White and red mottled clay with surface eroded.....7–3 feet
3. Thin laminated sand with clay partings.....2 feet.
4. Laminated sand. in colors from black to white, exposed.... .10 feet.

No. 1 represents our Lafayette deposit, and I am inclined to place even the lower members as belonging to an earlier episode of that period.

In a neighboring washout, the red loam has a thickness of ten feet, underlaid by beds of whitish clay from 4 inches to 2 feet thick, intercalated with sand beds. Some of these sands are deep red, and others gray or white; beneath the whole are white sands. This section reaches a total thickness of about 25 feet.

From Fort Valley southward, the level plateau is covered with the red loam of argillaceous texture. West of Winchester, sections of this superficial material are well shown, where about eight feet of orange clayey sand rests upon laminated sands in white and colored bands. Upon the higher plateau, above Montezuma, the red loams prevail; but in descending to the Flint valley, the underlying gray sands form the surface soils. This is true over the lower country about Montezuma, and, indeed, for many miles in the direction of Americus. But the higher hills are everywhere capped with the orange loam.

Along the Flint river, many sections of the Lafayette loam are seen forming the bottom lands. The best section, in its relation to other rocks, is shown about two miles south of the great bend, in the river in closest proximity to Everett station. That section is here given.

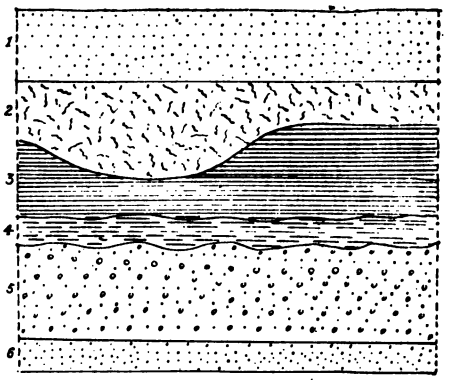


FIGURE 7.

1. Orange loam or sandy clay.....8 feet.
2. Light bluish clay with irregular joints stained red.....6 feet.
3. Orange and gray clayey sand, unconformable below.....5–9 feet.
4. Coarse light bluish clay, unconformable above and below.....3 feet.
5. Orange-colored quartz gravel, unconformable above .....10 feet.
6. Coarse white sand cemented with clay, exposed.....4 feet.

The upper three members and the fourth member represent two distinct episodes, as shown by the unconformity. At the ferry, between Winchester and Garden Valley, the mantle of orange loam is well developed, reaching from near the river to the surface of the country 210 feet above it, thus occupying alike the hill and the old valley. Here, the deposit is of a more sandy character than adjacent to Fort Valley, and the lower beds are cemented into occasional blocks of ferruginous sandstone.

At Oglethorpe, there is an exposure of coarse yellow and white sand interlaminated, into which there is a valley carved and refilled with clay, belonging, probably, to modern river overflows.

Just below the mouth of Camper creek, 12 feet of this formation appear, of which the lower portion is pebbly and rests upon gray and yellow sands. Where these superficial materials succeed the incoherent older formations, and where the exposures do not reveal unconformity, it becomes somewhat difficult to always distinguish the lower beds, which can be the more readily done where a limestone country marks the upper limit of the subjacent formations.

The limestone bluff above the old Danville ferry shows from 12 to 15 feet of orange-colored loam, traversed by an irregular layer of stones derived from the underlying rock. Beneath this loam ten feet

of yellow and white laminated sands occur. From this lithological relation there is but little difficulty in distinguishing the more sandy members of these surface deposits from the older Eocene. Just below the foot of this same bluff, occupying a valley excavated out of the original limestones, there is the following section:

1. Orange or red loam.....15–20 feet.
2. Layer of small boulders and pebbles.....1–2 feet.
5. Gray, white and yellow sand.....15 feet.

Between the railway bridge and Warwick, the orange loam is covered with three or four feet of washed gray sand. To a smaller extent this superficial sand occurs further up the river, and and was there identified as a deposit from the overflow of the modern river. But, in descending the valley, this superficial dry gray sand becomes more and more pronounced, and at elevations far above the overflows of the gradually descending river; and hence, it is not a modern deposit; moreover, this sand in various places is seen to rest unconformably upon the orange loam deposits, and thus it belongs to the distinct Upper Columbia episode. It is this formation, or its equivalent, that forms the sandy plains of the lower Flint valley.

At the rapids, about five miles directly above Albany, Eocene limestone boulders occur in clayey deposits, which appear to graduate into the orange loam in one place, whilst overlying a coarse gray sand in another portion of the same bed. This exposure is remarkable, and reveals a condition rather difficult to explain—whether boulders could possibly have been moved by waves, or whether the clay and boulders are residual, and commingled only along the contact, with the overlying sandy clay, which was not deposited until after some coarse sand beds had been formed upon the side of the boulder bed. Near the mouth of Dry creek, many miles farther down the river, there is a repetition of these conditions just described. Near Detroit Post-office, the orange loam, with a thickness of from four to seven feet, is underlaid with laminated sands of different colors. Below the mouth of Pond creek the orange loam rests upon laminated clay, which is of the Lafayette series. About five miles further down the river we find the following section:

1. A surface of whitish or gray dry sand, resting unconformably upon.....2–6 feet.
2. Orange or red sandy loam, with eroded surface.....7–1 feet.
3. Laminated sands of different colors.....7 feet.

This section, then, represents an actual unconformity between the superficial sand and the orange loam. This nonconformity is also displayed above Bogg's Ferry, by the superficial gray sand resting upon the eroded surface of the lower gray sand, without the intervention

of the orange loam. At an angle in the river, midway between Bogg's Ferry and the mouth of the Ichawaynochaway, there is a curious exposure. The rock is covered with a light bluish clay, succeeded by a whitish yellow and red mottled clay, in the top part of which there are boulders like the subjacent limestone. The top of this clay is eroded, and, covering the whole, there is a thick capping of the orange or red loam. Nearly opposite this last bank the light basal sand, overlying the limestones, is succeeded by a light blue clay, above which is the orange loam. The importance of this succession is, that occasionally the orange loam rests upon young clays, although it more commonly succeeds light colored sands along a considerable portion of the Flint river.

Whilst the high terrace plains in this region extend over the country far beyond the river margin, yet a few modern terraces are shown, marking the subsiding of the base level of the river erosion. Thus, near the mouth of the Ichawaynochaway, there are preserved three well marked modern terraces.

Below this point, there are many exposures of these superficial deposits generally characterized by the orange loam resting upon gray sand. Very commonly the loam is covered with a layer of gray sand from one to eight feet in thickness. This condition obtains to the last bluff seen along the Flint river, below Bainbridge. But one point, seven miles above Bainbridge—the Red Bluff—should be noticed. This is the face of a terraced plain rising fifty feet above the river. The orange loam upon one side of a washout has a thickness of twenty feet, upon the other thirty feet. Midway through it, there are irregular patches of light colored clay. A portion of the red deposit may be considered a sand. Below the sand there is a bluish irregularly jointed clay, beneath which the White Limestone occurs. The sand is cemented by iron so as to form a ferruginous sandstone.

LAFAYETTE AND COLUMBIA MANTLES IN THE CHATTAHOOCHEE VALLEY.

In the vicinity of Columbus, both the Lafayette and Columbia formations are best shown in the railway cut, and in the ravines upon the Alabama side of the river. The upper of these consists of about ten feet of red loam underlaid by from one to four feet of coarse gravel. This formation rests upon the eroded surface of the Tuscaloosa series. The Columbia series rests unconformably upon the older and constitutes the plains at Columbus, which rise about one hundred feet above the river and 260 feet above the sea. This later formation is made up of bluish sand and alluvial clay. About five miles south of Columbus, just beyond Upatoi creek, on the road to Cusseta, there are other fine exposures of the older deposits. (See figure 1, page 28.)

1. Orange loam,.....10 feet.
2. Laminated, colored sands with a streak of whitish clay; this bed is completely cut through by the valley of an ancient branch about twenty feet wide, which is now filled with the overlying red or orange loam.....6 feet.
3. White and stained clayey coarse sand.....8 feet.
4. Gray sandy clay.....6 feet.

On neighboring hills, the gravels are found at an elevation of about 350 feet above the river, which is two or three miles distant.

At many points along the Chattahoochee river, this orange loam capping is characterized by drift logs at its base; these probably belong to the younger system of deposits, although sometimes of a different color from those at Columbus.

Steward's Hill, six miles north of Georgetown, displays the finest exposures of the Lafayette series seen anywhere in Georgia. This hill rises 265 feet above the river; the lower 145 feet belong to Cretaceous beds; the overlying 120 feet constitute the Lafayette sand or loam.

1. First bench of loamy sand, drab and reddish; the lower three inches cemented with iron.....30 feet.
2. Second bench, like the first, with sandstone cemented at base.....10 feet.
3. Ditto of a redder color, but at base there are three feet of sandy clay.....20 feet.
4. Variegated colored laminated clayey sands.....40 feet.
5. Ditto partially concealed.....20 feet.
6. Cretaceous deposits.....145 feet.

The lamination is not always well marked. The sands vary from white to red. Through one of the beds, there is a layer of coarse pellets, producing a fine conglomerate. In this region, the gravels occur along the sides of valleys tributary to the Chattahoochee, but are not found at Steward's Hill. The gravels appear to be characteristic of the plateau to which Columbus belongs. This condition is shown in the high terrace of Eufaula (125 feet above the river), where there is a thick gravel floor. That terrace is bounded on the west by hills covered with Lafayette loam. At Fort Gaines, a similar condition is found. The surface of the same terrace is covered with twenty feet of red clayey sand or loam, the lower part of which is composed of quartz gravel.

The railway cuts east of Georgetown expose excellent sections.

Along the river, about four miles above Columbia, Alabama, a fine exposure of orange loam was seen rising twenty or thirty feet above the river. In this loamy deposit, a piece of gneiss was found, in size 8x6x4 inches, and some smaller pieces of mica schist. These trans-

ported stones could not have been brought from a point nearer than Columbus, seventy-five miles distant in a straight line. They could not have been transported by waves, but were probably carried southward entangled in the roots of drift-wood. A smaller boulder was also found in the fine sands of Steward's Hill referred to above.

The terrace in the extreme southwestern corner of the State, near Chattahoochee village, has approximately the same altitude as at Columbus and Fort Gaines. Its surface and sides are covered, throughout a vertical range, of one hundred feet, with the same orange-colored sandy clay or loam.

From these descriptions, it will be seen that orange colored or red sandy loam extends throughout the whole length of the river from the highest altitudes of the country to the present flood plains. But there is also another series of superficial deposits, which rest unconformably, and at lower elevations, upon some of the red loams—the second bottoms.

LAFAYETTE AND COLUMBIA MANTLES IN THE INTERIOR OF SOUTHWEST GEORGIA.

Throughout the highlands of Decatur and Thomas counties conditions similar to those along the great rivers prevail. Thus, near Whigham station we see the following section:

1. Orange or red loam passing beneath into a lighter and more clayey layer ..... 4–8 feet.
2. Reddish and light colored mottled clayey sand with light patches of clay; only the upper portion is laminated; the lower part is somewhat sharply defined, and in other places apparently passes into ..... 8 feet
3. Laminated white and purple clay with red micaceous and sandy partings. This bed shows undulations ..... 3 feet.
4. Laminated red sand with clayey partings ..... 6 feet.

No. 1 belongs to the Columbia and possibly to the No. 2 and No. 3 Lafayette series. In the Attapulgus creek district, the orange or red loam varies from two to eight feet, and often passes imperceptibly into bluer clay, which occasionally graduates into banded clay.

On the Thomasville road, nine miles east of Bainbridge, the orange loam is conspicuous. There, a rolling hill-country, covered with this red deposit, bounds the sand-covered plains of Bainbridge. In a washout, the lower portion of the loam, which is 8 or 10 feet thick, contains irregular pockets of cherty fragments derived from the adjacent rock. At one point, this loam rests upon blue clay. In some localities, this subjacent clay is seen; at others the underlying material is a quicksand. The explanation of this condition was not

obtained until the observation was made in the railway cut about a mile west of Climax, on the road to Bainbridge, showing the following section:

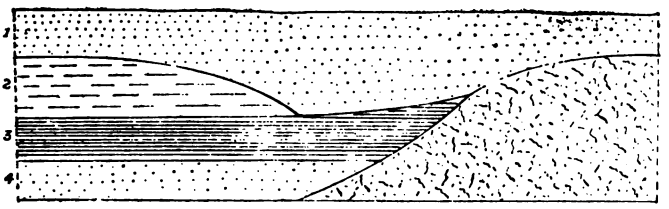


FIGURE 8.

1. Orange or red loam passing below into a red and white clayey material, with some ferruginous concretions... 4–12 feet.
2. Laminated sands, in colors from white to black, with clay film partings..... 0–12 feet.
   At the west end of this section the sand is traversed by two seams of white clayey matter about 8 inches thick. It rests upon the eroded surface of
3. Whitish sandy clay..... 8–4 feet.
4. A band of sand from white to dark red in color, with some slightly clayey seams; exposed in places..... 8 feet.
5. Miocene, white sandy clay, exposed..... 0–16 feet.

No. 2 is wanting at the eastern end of the cut, but No. 1 rests upon from 10 to 15 feet of a sandy clay (Miocene) No. 5 which is not exposed at the western end of the section. Two unconformable deposits succeed the Miocene; but the lower of the two is sometimes completely wanting. Thus is explained the occasional absence of the sand, which is so often seen beneath the loam; namely, on account of its entire removal by erosion, before the deposition of the superficial red loam.

In many places, in these southern counties, the orange loam rests directly upon the deposits of apparently Miocene age. On the higher lands, the loam is not covered by any superficial material, but at elevations inferior to 200 feet above the sea, a superficial water-washed sand (Columbia series) may be seen, at many places, resting upon the loam. This superficial sand, at the phosphate beds, west of Boston, has a depth of a foot and a half. Throughout the lower and more level counties of Mitchell, Miller, Baker, Dougherty and Calhoun, the loam is apt of itself to be sandy, and covered with a sandy soil, either directly derived from the loam, or perhaps indirectly by the waves acting temporarily in some lagoon, which may formerly have

covered these counties. This last explanation appears to be sustained by the presence of duny sand ridges rising to a height of twenty feet, on the east side of the Flint river, opposite Newton.

A further characteristic of this orange or red sandy clay or loam is that its lower portion consists of a bed of gravel, in the vicinity of the ancient valleys. Thus, on the hills, above the last bridge over the Upatoi creek, the gravel occurs at an elevation of 350 feet above the Chattahoochee river, which is two or three miles distant. These pebbles diminish in importance on going southward, and were not seen near the Floridian boundary. But, as if to take their place, fragments of limestone—or in phosphatic regions, pebbles of phosphate, occur in portions of the beds. In this way, the character of the subjacent rocks is detected by the hillocks being covered with such loose masses, secondarily derived from the drift.

As was noted before, at one or two points along the Chattahoochee, drift boulders, from the crystalline rocks far away, were found. The same holds true along the Flint and in other regions. This evidence of partial transportation of the material of the loam is not needed to explain its source; for it is generally so charged with hydrated micaceous particles as to at once tell that a considerable portion of it has been derived from the decayed crystalline rocks of Middle Georgia; which had also contained the quartz veins, whence the quartz pebbles, in the gravelly portions of the formation, originated. However, their partial local origin is attested by the presence in many localities of fragments of the subjacent rocks.

From the study of the sections given, and the general impression left by the investigation, there is seen to have been more than one episode of deposition; but the lithological character has a degree of uniformity from the fall line, between Columbus and Knoxville, to the Floridian boundary, although interrupted by the superficial sands in Macon, Marion, Muscogee and Chattahoochee counties, and by the more sandy surface of the country bounding the lower Flint river, so as to render the separation somewhat difficult. This is not to be wondered at, for the younger material was, to a large extent, only the older material redeposited. No fossils have been found in any of the beds, except drift-wood. seen along the base, in the Chattahoochee valley.

Whilst here referring to variation in character, it should be noted that the loam overlying the more clayey deposits of the Ripley series, is much more argillaceous, and contains a larger portion of ferruginous pellets than seen elsewhere.

The thickness of these loams may be placed, on the average, at twelve feet, although varying from zero to twenty. When the gravel is present, it may reach a thickness of ten feet, but rarely more than four. The sandy formations, underlying the loam, in Southern Geor-

gia, may also reach another twenty feet in thickness, but it is impossible, at the present juncture to give an average estimate. That these later deposits may have a considerable thickness, is shown at Steward's Hill, above Georgetown, where one hundred and twenty-five feet of the Lafayette series are exposed.

The whole question of surface deposits in south Georgia needs further investigation. Indeed, the disconnected details given in this chapter, are the result of the necessarily speedy preparation of this preliminary report without due time for the digestion, even of the facts which have been collected; and hence, the extraordinary length of this chapter, in which there has been an attempt to set forth the facts, in a condition for future use. A few words of explanation may, however, be given.

THE PHYSICAL GEOGRAPHY SUCCEEDING THE MIOCENE PERIOD.

In Southwest Georgia, there are no Miocene deposits known to be of more recent age, than those of the middle portion of the period. The Pliocene formations are also absent, unless the Lafayette series belongs to that period. Overlying, alike, all the formations in Southwest Georgia, the superficial deposits, described in this chapter, are found. Going outside of the region, we learn something more of the history of the country under consideration. As has been shown by the writer in "High Continental Elevation preceding the Pleistocene Period;"* and "Post Pleistocene Continental Subsidence,"† that the American continent stood at from 3,000 to 5,000 feet, or more, above its present elevation compared with the sea level. This high elevation occurred during the later Miocene or Pliocene period. In fact, the Pliocene period was one of general continental, elevation not only of America but also of Europe; for, there are but limited basins of Pliocene formations found above sea level. This question of elevation, for the southeastern part of the continent, is one which will form a future chapter in the writer's investigations.

During this high continental elevation the great rivers, such as the Chattahoochee and Flint, excavated valleys, out of the comparatively recent Cretaceous and Tertiary deposits, to depths of from 200 to 350 feet, sometimes with a breadth of several miles. Along the Flint valley, this erosion undermined and washed away the softer portions of the Upper Eocene limestone formations, whilst the harder rocks remained, often in accumulations of great, water-worn boulders, noted on a former page. Another result of the high continental elevation in Southwestern Georgia was the establishment of the extensive subterranean

*Bulletin Geol. Soc. Am., Vol. I., 1889.
†Ibid., Vol, II., 1890.

drainage, and the formation of caverns in the limestone, which are very extensive. Some of the limestones must have a depth of nearly 1,800 feet in Southwest Georgia (1,600 feet, at Thomasville, where Mr. Thompson reported caverns to have been found in the artesian well.)

Following this high continental elevation, there was an epoch of subsidence, when the oceanic waters covered Southwest Georgia and washed eminences now eight hundred feet above the sea, along the fall line near Knoxville. It was during this Lafayette subsidence that a portion of the loams and sands, described in this last chapter, were spread over Southwest Georgia. Again, the continent rose and the rivers remoulded the surface features, carving out new valleys. Another unequal subsidence (the Columbia), to probably a maximum depth of nearly three hundred feet, followed. During this second subsidence, which left Southwest Georgia partially covered, another formation was spread out over the plains of Columbus, Fort Gaines, and that plateau which characterizes the Chattahoochee river, and reached over the low counties of the Flint district. From the evidence along the Flint river, there appears to have been a temporary re-elevation to a limited extent, followed by a third partial depression, which caused the back waters of the rivers to spread over the low counties, probably forming the lagoons, in which were deposited the superficial soils of Miller, Mitchell, and Baker, and portions of other counties. This depression may not have exceeded one hundred feet, which would have permitted the slackened waters of the great rivers to overflow the low country.

CHAPTER VII.

ARTESIAN WELLS AND UNDERGROUND DRAINAGE.

A few tables of artesian wells have already been given, and from these records we have been able to extend our knowledge of the underlying formations. Most of the borings made have been the result of pure venture, and only occasionally have the records of the wells been kept. In the borings, it is easy to determine whether the drill be on a hard flinty rock, on a hard limestone rock, on a hard clay, or an incoherent sandy deposit. But when the earthy matter, being penetrated, consists of a succession of comparatively incoherent sands, clayey sands or sandy clays, or soft marly deposits, the recognition is not so easy. Moreover, by adopted methods of washing out the materials by stream of waters, these fine sediments are not so readily distinguishable, for the clay derived from clayey sands and the fine marly matter, alike render the overflowing water turbid, and obscures the included sand. To the well borers it has generally been of no interest to preserve records, which would have been invaluable to the survey. As an example of the want of geological knowledge, the following may be cited: The manager of a certain well said he expected to get water at a certain depth, which he calculated would reach the Albany water-bearing strata. When thus informed, I told him that he had been laboring in the dark, for already, geologically speaking, the well was far below the Albany strata. Other efforts have been made in Georgia to get deep artesian wells in the crystalline rocks, which would not have been undertaken with the advice of any experienced geologist. In all Southwest Georgia, I regard the question of domestic water-supply the most important economic question, and after that, the drainage of such portions as are subject to malarial conditions. Whilst much of the southwestern portion of the State is well drained and healthy, yet, the numerous ponds and occasional sloughs in the comparatively level country, are unwholesome. Immediately adjacent to the rivers, the overflows render the districts somewhat unhealthy. With the drainage of the ponds and sloughs, and with artesian water, there are few districts in Southwest Georgia which may not be rendered comparatively healthful in the future. Even such towns, as are situated near rivers subject to high waters, and that are now provided with artesian wells, have become healthful. Consequently, I have given primary consideration to this subject.

The following imperfect well-records have been of service to me in both the study of the underlying geological formations, and in the investigation of artesian water-supply:

BAINBRIDGE WELL.

See page 55.

THOMASVILLE WELL

This meagre record was furnished by Mr. E. O. Thompson, superintendent of the water-works. It is greatly to be regretted that the full record of this deep well was not preserved.

1. Red and blue clay and sands to ..... 162 feet.
2. Limestone to ..... 225 feet.
3. Shell rock with water at ..... 310 feet.
4. Rubble rock at ..... 360 feet.
5. Shell rock with a copious flow at ..... 410 feet.
   (From this level, water rises to within 210 feet of surface).
6. Water at ..... 1,400 feet.
7. Bottom of limestone ..... 1,680 feet.
8. Quicksand thence to ..... 1,820 feet.

The water derived from 410 feet evidently comes from the Miocene deposits. The quicksand beneath, 1,680 feet, probably belongs to the Lignitic series. The water does not rise in the well higher than 210 feet below surface. This is not to be wondered at, for we have no land higher than the Thomasville ridge for a distance of more than 50 miles.

THE QUITMAN WELL.

The best record obtained was furnished by Mr. S. S. Roundtree:

1. Clay and sand to ..... 70 feet.
2. Soft rock in seams ..... 100 feet.
   (Rock 3 feet, after which drill fell 6 feet into a stream of water to) ..... 109 feet.
3. Soft rock and sand, to ..... 186 feet.
4. A hard flint rock ..... thin layer.
5. Quicksand and hard rock in beds 1 to 3 feet thick to ..... 300 feet.
6. Sand and clay to ..... 340 feet.
7. Sand to ..... 385 feet.

The water rose from the stream at 109 feet to within 30 feet of top of well. This water is artesian, and would probably be found perfectly satisfactory. The geology of this section has not been studied sufficiently to locate the horizon of the water more than being in Miocene beds.

JESSUP WELL.

Although outside of the district of this report, the record of this well will here be added, without criticism.

1.	Sand to	10 feet.
2.	Quicksand to	14 feet.
3.	Yellow clay soil with layers of quicksand to	26 feet.
4.	Quicksand to	52 feet.
5.	Limestone to	55 feet.
6.	Quicksand to	65 feet.
7.	Limestone to	78 feet.
8.	Clay with sand to	233 feet.
9.	Soft spongy rock to	237 feet.
10.	Blue marl to	490 feet.
11.	Water-bearing quicksand. Water rose to within 33 feet of top.	

CAMILLA WELL.

A well was sunk at Camilla to about 600 feet, when water was obtained, but not a flowing stream.

ALBANY WELL.

Several wells have been sunk at Albany and flowing water has been obtained. The record of one of these was furnished by Mr. Charles Tift, and also samples of boring from several depths. This well has an elevation of about 20 feet above the railway station:

1.	Surface soil and red clay to	23 feet.
2.	Light clay, white sand, colored clays and white lime rock to	55 feet.
3.	Flinty rock to	60 feet.
4.	Limestone with clay seams to	315 feet.
5.	Thick rock to	319 feet.
6.	Quicksand with a rocky stratum at 440, and lignite just above rock, to	480 feet.
7.	Blacksand	thin layer.
8.	Blue marl strata to	678 feet.
9	Porous water-bearing beds to	732 feet.

Samples were taken and examined as follows: Marl at 26 feet; limestone at 40 feet; oölitic or coral sand from 110 to 115 feet; a lime-rock, 5 feet thick, at 160; gray rotten limestone from 180 to 200; shell rock at 310; shell marl at 315 to 320; lignite at 340; coarse quartz sand with chips of gray limestone, 350; shell limestone, 360; clean sharp white sand in different beds between 360 and 425; lignite at 440; green slightly calcareous fine sand, with a little clay between,

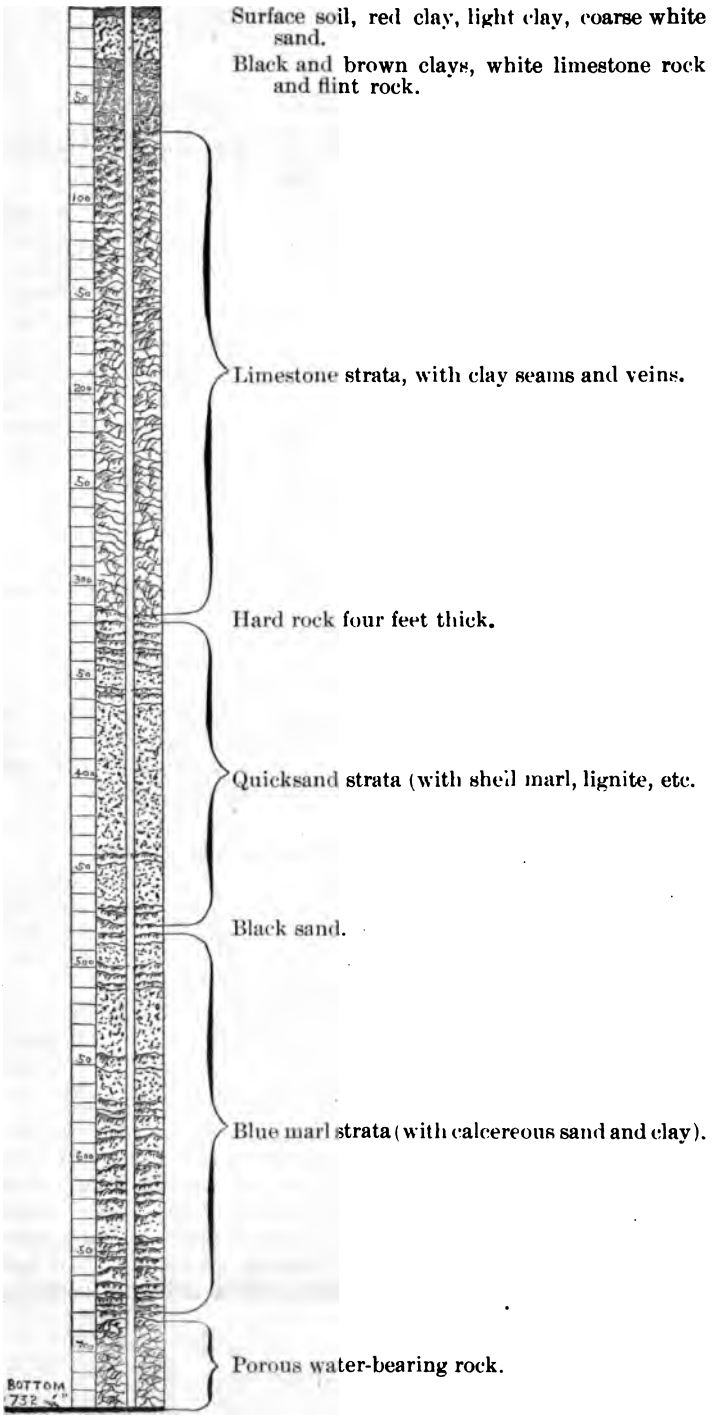


FIGURE 9. (MR. TIFT'S WELL AT ALBANY.)

485 and 678; a water-bearing coarse quartz sand, with calcareous particles, at 660.

The upper 320 feet represents the lower portion of the White Limestone and the whole of the Claiborne series. The next 40 feet most nearly resemble the harder beds of the Upper Buhrstone. Below this horizon, the well penetrates the Lower Buhrstone and passes into the middle or lower portion of the Lower Eocene formations. Part of the lignite beds are situated near the Bashi series. The records of this well have proved invaluable.

THE FORT WELL.

The first artesian well, in Southwest Georgia, was sunk by Mr. J. P. Fort, at a point about sixteen miles westward of Albany. The record of this well is thus given by Mr. Fort:

1. A few feet of surface clay, followed by limestone boulders to 65 feet.
2. Limestone, with silicified layers, containing shells and traversed by subterranean streams to.....150 feet.
3. Blue marl (clay?) to .....165 feet.
4. Shell rock, sand, rock and marl (clay); water rose to within 14 feet of surface, to.....260 feet.
5. Sand tinted blue; a layer of very fine white sand at 370 feet; below which some coarse sand with shell fragments and sharks' teeth; to.....380 feet.
6. Blue clay and sand rock in alternate layers to.....410 feet.
7. Blue clay with soft sand rock to (flowing water).....490 feet.
8. Sand and clay forming water-bearing stratum to hard rock at.....530 feet.

This is a flowing well.

These two last wells, and that at Bainbridge furnish the most important records obtained. The water supply comes from the Lignitic or Lower Eocene series.

LEARY'S WELL.

A well was bored a depth of about 600 feet, but the records were not preserved. Water was obtained.

ARLINGTON WELL.

1. Chalky clay..... 20 feet.
2. Sand and white clay.....
3. Shell rock..... 5 feet.
4. Very coarse sand.....
5. Shell rock, etc., to.....355 feet.
6. Hard rock, siliceous, with soft places, to.....390 feet.
7. Hard dark clay.....500(?) feet.
8. Coarse, dry micaceous sand.....540 feet.

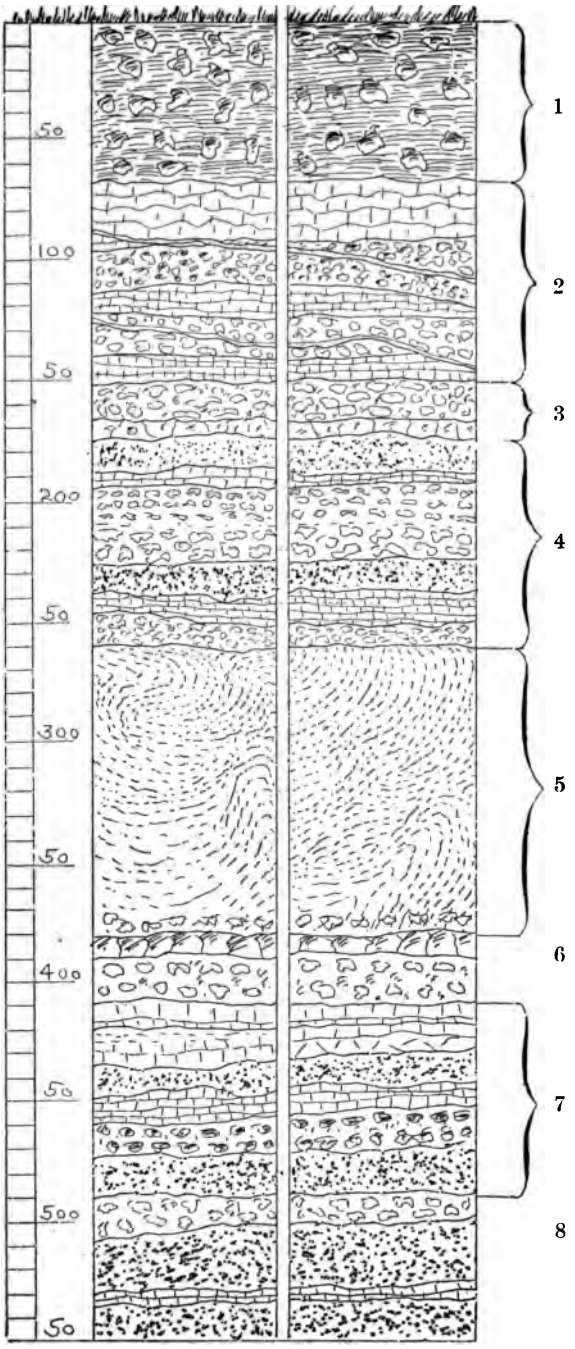


FIGURE 10—THE FOBT WELL.

CORDELE WELL.

1. Soil, clay and chalk, about..... 40 feet.
2. Coarse red sand to..... 60 feet.
3. Loose boulder rock, through which the tubing was driven; fine, white sand was also found, to..... 68 feet.
4. Different colored marls (clays or true marls?).....168 feet.
5. Limestone and shell rock, with an intervening layer of sand, to.....400 feet.
6. Sand and shell rock to.....475 feet.
7. Quicksand to.....535 feet.

Owing to an accident this well was not completed.

These last two borings were kindly furnished me by Mr. E. R. Hathaway, well contractor, of Montezuma.

These latter wells were sunk into the Lignitic series.

FORT GAINES WELL.

The record of this well is lost, but it reaches a depth of about 650 feet. The lower 350 or 400 feet of these strata belong to the Ripley or Upper Cretaceous system, which is overlaid by the impervious beds of the Lower Eocene limestones. The water rises to within 20 feet of the top of the well.

CUTHBERT WELL.

This well was sunk to a depth of 1,000 feet, but the record was not kept. From a point between 340 and 400 feet water rose within 30 the surface, and at 550 feet the water rose to within 70 feet of the surface. The conditions are similar to those at Fort Gaines. The water comes from the upper portion of the Ripley series, of which the bed between 340 and 400 feet is probably identical with the water-bearing bed at Fort Gaines.

DAWSON WELL.

Clayey white sands to..... 40 feet.
Coarse sand to..... 80 feet.
Limestone, followed by sand and rock repeated, to.....650 feet.
Quicksand to.....660 feet.

Water rose near to surface in the pipe, but does not flow. This well is also in the Ripley series, overlaid by a moderate thickness of of the Lower Eocene strata.

AMERICUS WELLS.

One well was sunk to a depth of nearly 1,600 feet without success, but of this there is no record. Another well, at the railway station,

was sunk to a depth of about 500 feet, with a water supply. A new well at the water-works gives the following section:

1. Surface clay	3 feet.
2. Blue clay	70 feet.
3. White marl and limestone	11 feet.
4. Hard limestone	6 feet.
5. Blue clay	7 feet.
6. Limestone layer	½ foot.
7. White sand	5 feet.
8. Rock and clay	123 feet.

Whether the water will flow from the wells, or require to be pumped short distances, will be a matter of local determination. For smal er wells this can easily be accomplished by wind-mills as in many other localities. For the occurrence of artesian water it is necessary that the beds should be covered by impervious layers; but where these layers are tapped by great river valleys, then the conditions may be such as to allow the subterranean waters to be discharged without being forced upward through the artesian borings to the surface of the ground.

Whether the Cretaceous country north of the line between Fort Gaines and Montezuma contains a sufficient number of impervious beds of clay to permit of the accumulation of artesian waters or not, cannot be reported upon at present.

Flowing water cannot be expected from a large section of the district in which there may be reasonable expectation of a water supply, as the original source of the water does not come from great elevations to the north.

In the country underlaid by Miocene strata, the water supply must either be looked for in comparatively shallow wells, or at great depths, after penetrating the thick Upper and Middle Eocene and reaching the lower strata.

Whilst throughout much of Southern Georgia, the Upper Cretaceous and the Lower Eocene beds are capable of furnishing water, we may look to the caverns in the limestones of the Eocene formation for the drainage of many unwholesome swamps or ponds. As has been pointed out in this report, many of the lakes are evanescent, owing to the clogging and reopening of the subterranean passages. As some of the Eocene limestones are very cavernous, it is not unreasonable to expect, in the regions of the ponds, caused by sinks, that by boring, outlets could be very often obtained; if not by the subterranean channels in the limestones, then by some porous sandy strata beneath. Such results have been accomplished elsewhere, and this method would simplify the drainage question in much of the flat country where it is most needed.

It may not be unsafe to predict that the time will come when much of Southwest Georgia will be supplied with artesian water, and the malarial ponds, where such occur, be drained. It is to be hoped that the data set forth in this report will call attention to the value of artesian water, and the importance of the preservation of the well-records, which in the hands of a geologist, can be used in extending our knowledge of the water supply. It will simplify the question of the water supply for farms as well as towns. But in this preliminary report, the first that has appeared relating to Southwest Georgia, only an outline can be expected, which sooner or later, can be supplemented, as the difficult work of outlining is now accomplished.

Speaking in a general way, the present surface wells, in Southwest Georgia, pass through the orange loam into the beds of sands, or of sand and clay, which generally underlie the red loam. They vary in depth from twenty feet to one hundred; at which depth they enter the Cretaceous or Tertiary deposits. The deeper wells are generally bored with a diameter of about eight inches. In many cases the well water is excellent. However, in the lower and more imperfectly drained districts, pure water cannot be expected from surface wells; for whilst sand acts as a filter, still, it is too imperfect to remove all unwholesome matter. The artesian water, being protected from the surface drainage, by impervious layers, and coming primarily from distant and more elevated regions, must, of necessity, be more wholesome than ordinary surface wells.

CHAPTER VIII.

PHOSPHATE, LIMESTONE AND MARL DEPOSITS IN SOUTHWEST GEORGIA.

PHOSPHATES.

Phosphate beds are now being worked three miles westward of Boston, in Thomas county. These beds were the first reported upon by me to the Governor, in September, 1890. Since that time, further developments have been made, and a more extended knowledge of the associated beds, have been acquired. In the first place, the subjacent rocks are fossiliferous Miocene limestones, probably belonging to the middle part of that system. These limestones are highly silicified, in their upper portion, and consist, in places, of scarcely more than a so called flint, in which the same fossils occur as in the adjacent limestone. This so-called flint is more or less translucent, light, and softer than the normal condition. Upon exposure it becomes white; in short, it appears to be a variety of opal, rather than quartz; and some of it contains traces of phosphoric acid, but it was primarily formed from the silicification of limestone. Upon this, and more or less mixed therewith, are the beds of phosphate. The phosphate, in part, appears to have been formed contemporaneously with the flint, owing to the close commingling of some of the deposits.

The phosphate occurs in more or less concretionary masses, which sometimes make up the great mass of the deposit, to a depth of ten or fifteen feet, or more. Again, it is scattered through the clay from which it can be separated. The phosphate may be in a very hard form, or it may occur as a soft white powder; resembling calcareous marl. The appearance of the phosphate is so extremely variable, that it is never safe to pronounce an opinion upon even similar materials from two different localities without careful examination. White is the prevailing color, but it is often tinted, and greenish color is common. Iron and alumina are objectionable mixtures, as these not only reduce the quantity of the phosphate, but also make a less desirable product. When the iron is present in objectionable proportions, it appears in the form of bright stains, or rust. The presence of alumina requires more careful determination. The phosphate, in the pits now being worked, is of high grade, running to 70 per cent. bone phosphate. All the phosphate beds occur in pockets of larger or smaller size, and none can be found in uninterrupted sheets. The character of this phosphate is similar to

that in the interior of Florida; where most commonly, it is derived from phosphatization of limestones, as frequently shown by even the phosphatized shells being well preserved. But in Florida, I have occasionally seen the phosphate deposits intercalated with white sea sand. The beds of phosphates commonly occur on the edges of slight undulations of the country; as the phosphate has the ability of resisting meteoric solution, to a greater extent than the limestone beds. Phosphate beds, west of Boston, have been found in several localities. At the largest pit opened, portions of the phosphate beds are covered with stratified clay, resting in part at an angle of 45 degrees, and internally often showing slickensided surfaces, thus recording the great lateral thrusts since the deposit was found. This disturbed clay is covered with an orange loamy clay, which reaches from 4 to 10 feet in depth, and is succeeded by about 18 inches of superficial washed sand. In an adjacent well, the orange loam is underlaid by red sand and a laminated blue clay, dipping at 30 degrees to the southward. This locality has an elevation of about 160 feet above the sea.

The exact age of the phosphate beds cannot be determined. They are newer than the Middle Miocene limestones upon which they rest, and we find them beneath the disturbed layers of clay, which underlie the Lafayette loam. The importance of these disturbed beds is considerable. They do not occur alone at the phosphate pits, but may be seen in several railway sections between the mines and Boston. These beds, I did not describe in the chapter upon the Miocene; but whether they belong to the Upper Miocene or Pliocene, must be left for future investigation. They form a distinct series or division; and in order to understand them better, the following sections along the railway are given: In the railway cut, just east of the phosphate switch, the surface is covered with a variable thickness of orange loam resting unconformably upon and filling a syncline, or basin, in white and purple clays, whose laminations are separated by red sandy parting. These rest upon a white and blue clay, rising as a dome from beneath the laminated clays. Between the last two divisions, at one point, there is a wedge of reddish clayey sand, at one point, which resembles the superficial red loams. In railway cuts, farther east, several sections were observed, and the following gives a generalized idea:

1. Orange loam passing, in its lower part, into..... 4 to 10 feet.
2. A bluish and reddish clay..... 3 to 20 feet.
3. Hard reddish sandy clay..... 2 to 5 feet.
4. Undulating laminated purple and white clay, with red sandy partings..... 5 feet.
5. White and yellowish mass rises, forming interruptions in the overlying masses..... 5 feet.

In one railway section, the beds, from 2 to 4, form a synclinal basin dipping at considerable angles, filled at one point to a depth of 15 feet with the loam of No. 1. No. 3 is twice repeated, including three bands like No. 2 and No. 4. The disturbances along the strata are considerable, so that No. 4 rests against or upon No. 1. This may be the result of land slides. In one place, No. 1 contains an irregular layer of large fragments of cherty rock. The structure is difficult of explanation, and the resemblance between some of the enlarged sandy partings and the surface loams is so close as not to be distinguishable, except by the stratification. These disturbed strata are probably of the same age as those at the phosphate beds and belong to a period intervening between the Middle Miocene silicified limestones and the overlying Pleistocene loams.

The fossils of the silicified limestone, underlying the phosphate beds, have only in part been studied, and Dr W. H. Dall has provisionally determined, for me, their approximate age as Middle Miocene.

The origin of these phosphate beds is not well understood. They are not derived from an accumulation of marine animal remains, but have been formed by the phosphatization of beds of limestone, whose structure and fossils remain. They have been formed where they now rest. The source of the phosphoric acid was from above, as the deposits diminish in richness in descending. This source was, probably, from the remains of maritime birds, similar to the leached guano beds on the coast of South America and elsewhere. As the organic matter decayed, the more or less soluble phosphoric acid turned the subjacent limestone into phosphate. This explanation will account for the irregular character of the deposit arising from the favored and unfavored resting places of the birds.

In some of the loams, adjacent to these nodular deposits of phosphate, considerable quantities of the mineral are found in the form of pebbles, having been derived by the action of the waves from the phosphatic rocks constituting the shore. Some of the clay is also found to be rich in phosphate, which is finely commingled with it.

The depth to which the phosphates can profitably be worked varies with the volume. The Charleston phosphates have usually a thickness of from 6 to 15 inches, although greater in places. Under these conditions they obtain from 300 to 1,200 tons per acre, which permits the removal of eight or ten feet of earth (according to Dr. Shepherd); usually 500 tons to the acre are necessary to pay expenses. Hence, the superior value of the deposits of Thomas county, which have a much greater thickness, will easily be seen, if they prove of extensive distribution. Moreover, the Thomas county phosphates reach a higher percentage.

There is a marked difference between the phosphates of Georgia and of the interior of Florida, on one hand, and those of South Caro-

lina and of the rivers of Florida on the other. These latter deposits are boulders or pebbles of the harder phosphate, which have been accumulated by waves and currents from the disintegration of phosphatized beds, such as those in the interior of the country.

The search for phosphates is rendered the more difficult, owing to the surface of the country being generally covered with the heavy deposits of loam or other Pleistocene materials; thereby concealing the subjacent deposits. But when limestones occur at the surface, the inexperienced are very apt to mistake every exposure of marly looking rock for phosphate,—the limestone being distinguished by its effervescence with acids; whilst the phosphate is soluble without effervescence. Still, the latter is difficult of recognition, as it is apt to resemble not merely the marl, but various arenaceous deposits, and requires to be determined by one familiar with its properties.

Phosphatic rocks are wide-spread over Thomas and Decatur counties, but the deposits so far found are not generally of extensive proportions except in the one locality described. I have found deposits of phosphates on Mr. Heard's property about six miles east of Thomasville, associated with exposed limestone; and from the loose stones, in the red loam, phosphatized rock was brought to me from several localities. In the southern part of Brooks county, there is a brecciated looking siliceous rock, which weathers into a white mass containing a small quantity of phosphate, but upon analysis it was found to be of little value. This peculiar rock appears to be composed of silica in an opal form, as it is soft and yet comparatively free from aluminous matter.

These southern counties, underlaid by the Miocene rocks, may afford other beds of phosphates, but as yet the country has been only slightly prospected beneath the loam. Still, where such occurs beneath more than 12 to 20 feet of earth, its value would be impaired or rendered doubtful owing to the cost of excavation.

In the upper portion of the Ripley series, along the Chattahoochee, phosphate matter has been noted (page 38), and in Alabama the same occurs above the Midway series, in beds wanting along the Chattahoochee, but which may yet be found to the eastward (page 49).

LIMESTONES AND MARLS.

Limestones for local building purposes, or for lime, may be obtained in many localities where the Tertiary rocks come to the surface. In the future, their use will be more extensive than now. The limestones suitable for construction are confined to the base of the Eocene system (as in the Midway series), and to the Claiborne and White Limestone series, of the Middle and Upper Eocene. Many of the beds are soft, or otherwise unfit for use, but other strata are compact, and harden on exposure. At very few places have quarries been

opened up, and hence their value is imperfectly shown in the weathered and superficial exposures, where the rocks are commonly worn into rough or pitted surfaces.

Closely associated with the surface limestones, in many localities, porous flinty rocks are found in large masses. These have been left upon the wearing away of the calcareous beds, and consequently they are generally found only near the surface or in caverns, as the siliceous matter in the compact rocks hardens the limestone, but does not usually occur as distinct beds. Such chert, when broken, makes excellent material for macadamizing roads. Some of the rocks can be used for millstones. Occasionally, they form beds that could be quarried for a variety of purposes, where a very hard rock is desired.

The softer and incoherent beds constitute marls, which are valuable adjuncts to agriculture, as they supply lime to such soil as is deficient in it, and also some phosphate. Whilst this material is a fertilizer and enhances the general value of the land, yet its effects are not seen immediately, until the plants reduce it into a condition favorable for absorption as plant food, which is eventually done, and the general quality of the land improved.

The distribution of the limestones is co-extensive with the geological formations indicated. The softer and marly beds usually occur in the Lower and Middle Eocene; they also occur in the Miocene formations on one side, and in the Cretaceous on the other. A complete list of localities cannot be given in this general report, as the survey has not had the opportunities of carrying out detailed work. The best exposures of the various rocks seen are adjacent to the rivers or streams, which have left the rocks exposed in the cliffs or in the river channels.

CHAPTER IX.

THE SOILS—BRICK CLAYS.

The soils of Southwest Georgia are directly derived from some portions of the Columbia or of the Lafayette beds; yet they present a considerable diversity, owing to the changing characters of these superficial accumulations, dependent upon the underlying geological formations. Thus, in the counties over the belt of the Tuscaloosa and Eutaw formations, the rolling table-lands are sandy, whilst the deeper valleys partake of the nature of the l wer formations, or are occupied by the second bottom, or Columbia deposits, as at Columbus. To the southward, there is a marked difference between the soils over the Ripley series, which are generally heavy red loams, and the more sandy loams overlying the Eocene limestones, or the heavy sands in counties along the Flint river. Again, the roll ing lands of Decatur and Thomas counties show an equally marked contrast. These differences arise, in part, from their mode of formation, but largely from their admixture with materials of local origin. The practical information wanted is, to know what they are best fitted for and their deficiencies. Such an investigation is quite out of the question until the survey is provided with a chemist, and until time can be given to the necessary work in the southwestern part of the State, which is absolutely necessary in order to make any agricultural report.

By way of illustrating this variation in the suitability of soils, we may call attention to the culture of Cuban tobacco in Decatur county. Thus, in the region of the Attapulgus, the variety produced is fine, and commands a price by which the yield per acre may amount to $200 or more. In other localities, with the same climate and similar appearing soils, the tobacco is found to be coarse and will command a much less price. This is attributable to the greater quantity of lime in the soil, which renders the weed more thrifty at the expense of delicacy of the plant, whereby the price is enormously diminished. The demarcation of such zones, of course, could only partially be attempted up to this time. These tobacco lands are coincident with the Miocene formation.

Of the other new industries, the pear culture is rising to prominence in the southern part of the State. In the belt west of Fort Valley, the peach and other fruit growing for early shipment has been

found very lucrative. But the delimitation of a belt of these rolling sandy soils on the higher lands of this portion of the State, freest from frosts, could not be determiued in the short period of work. The most favorable melon localities must share the same fate, in this preliminary report. These new industries will not merely diversify our products, but will enhance the wealth of the people, as has been effected in other States, and consequently increase the value of lands. Hence, the importance of carrying this geological survey to the limit of detailed agricultural investigation.

BRICK CLAYS.

The orange loams or the "hill clays," make bricks which assume a very rough surface and dark colored, from the fusion occasioned by the presence of large quantities of iron; hence, the favorite clay resorted to in brick-making, is that derived from ponds, which, however, has to be well-selected. At a few localities, where the Eocene clays come to the surface, such may be used for brick-making. The Columbus bricks, both common and pressed, are extensively used over a considerable portion of the State. This clay comes from the terraced plains of Columbus, and belongs to the Columbia division of the Pleistocene system. At various points, down the Chattahoochee, as far as Fort Gaines, this clay is used, but, from the latter point, the clays contain an excess of lime derived from the subjacent calcareous members of the Tertiary formations. Consequently, in the southern part of the State, the pond clays must be resorted to for brick-making.

CHAPTER X.

THE TIMBERS—THE CLIMATE.

THE TIMBERS.

Along the lower margin of the State, there is an admixture of valuable oaks with the long-leafed yellow pine, but, on approaching the northern boundary of the Miocene deposits, the timbers of the country are almost exclusively pine, except in the vicinity of the rivers, where there are white and red oaks, cypress and gums. This condition occurs throughout the northern part of Decatur and Thomas, Miller, Mitchell and the greater parts of Early, Baker and Dougherty counties; but on the more hilly lands of the Lower Eocene, and of the Cretaceous formation, we find an admixture of pine and of oak. In making the preliminary survey, extensive large pine forests, of valuable timber, were traversed. In localities, nearer the railways, the best trees have been cut off. At many points, the turpentine industry formed a conspicuous feature, but yet not enough to greatly reduce the value of the pine forests.

CLIMATE.

The compilation of such meteorological data as are accessible will not be attempted in this report. In the belt of country included in this report, we find the elevated ridges of Thomas and Decatur not merely desirable for winter residence, but also healthful in summer. The advantages of this belt for winter residences, for invalids and others, have been demonstrated by the success of Thomasvil'e, now resorted to by thousands of tourists. Numerous other places, along this belt are equally favorable, and along the railway, Whigham and Bainbridge are desirable. Bainbridge is on the Flint river. Its artesian water adds to its healthfuiness, and it is now rendered one of the most desirable localities for winter hotels. In the pine forest, a few miles from the railway, the picturesque Forest Falls might be made an attractive home. Although situated so far south, I have found that the climate and healthfulness of much of Southwest Georgia is equal to that of the more northern part of the State. No tourists' hotels have been built in the more northern part of this section of the State, but there is no climatic reason why they should not be constructed at many points. A new hotel is in process of construction at Americus which may rival those farther South. On the higher lands of this section of Georgia, under consideration, we find some of the most desirable portions of the State, with an excellent climate.

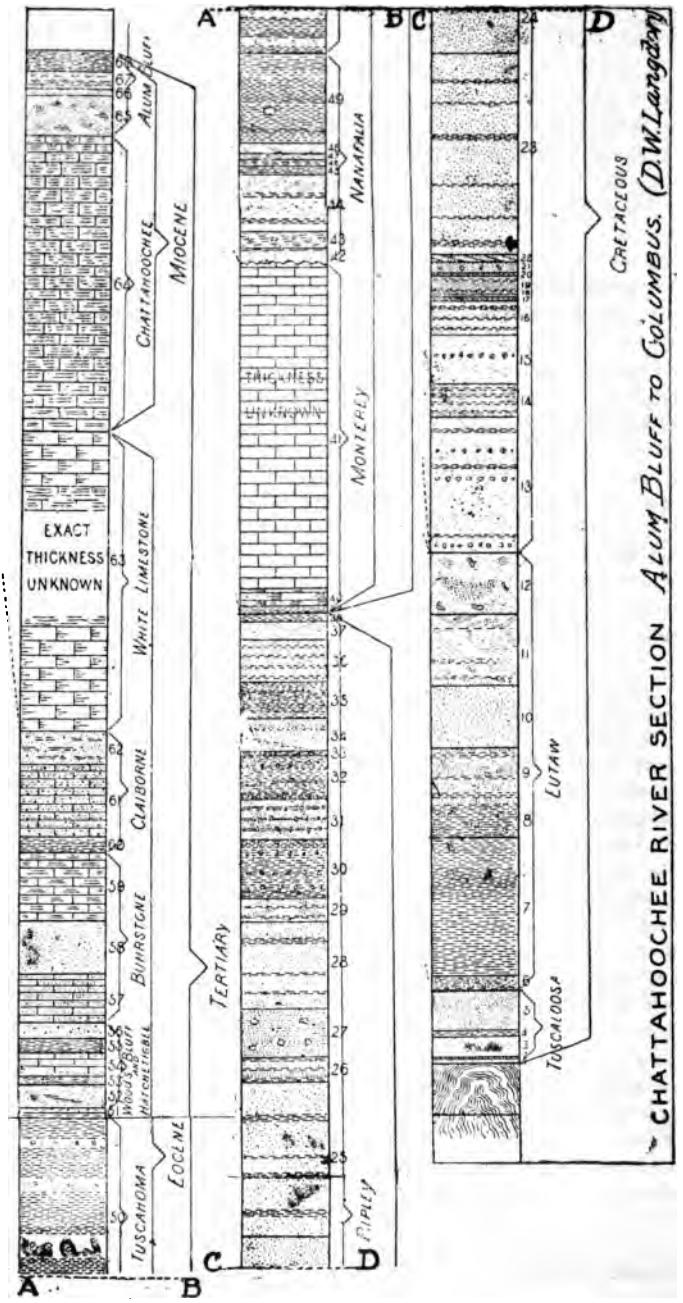

CHATTAHOOCHEE RIVER SECTION ALUM BLUFF TO COLUMBUS. (D.W. Langdon)
A
B
C
D
EXACT THICKNESS UNKNOWN
THICKNESS UNKNOWN
ALUM BLUFF
CHATTAHOOCHEE
MIOCENE
WHITE LIMESTONE
CLAIBORNE
BUHRSTONE
TERTIARY
EOCENE
TUSCAHOMA
NANAFALIA
MONTEREY
RIPLEY
CRETACEOUS
LUTAW
TOMBIGBEE

FIGURE 11.

CHAPTER XI.

GEOLOGICAL SECTION ALONG THE CHATTAHOOCHEE RIVER FROM COLUMBUS TO ALUM BLUFF.

By D. W. LANGDON, A. M., F. G. S. A.

[This section equally concerns Geergia and Alabama, and is therefore published by J. W. Spencer, State Geologist of Georgia, with the consent of E. A. Smith, State Geologist of Alabama, and of the author

The joint explorations of the Chattahoochee river were made by the Geological Surveys of Alabama, Georgia and the United States. The use of the following excellent, detailed section aided the progress of that survey and saved duplication of work. Its publication gives minute details as to character of strata.

The following section is down the river, but it is in geologically ascending order.

TUSCALOOSA SERIES.

1. Light green, highly micaceous sand, resembles weathered schist, and but for occasional water-worn pebbles, might be mistaken for schist ..... 3 feet.
2. Hard clay stained by ferruginous matter, breaks with conchoidal fracture ..... 1 foot.
3. Hard, white coarse-grained sand, held together by white clay ..... 15 feet.
4. Red and gray variegated sandy clays (typical Tuscaloosa), shows, at water's edge, mouth of Bull Creek .....

EUTAW SERIES.

5. Strongly cross-bedded coarse sand and pebbles with some few fragments of schist, and just enough white clay to hold the mass together. The quartzose pebbles are all well water-worn, while the softer bits of schist are but slightly abraded. This stratum varies in color from white to lemon yellow and in places green, while the upper part becomes purple and yellow variegated. This last phase is most strongly developed at Thomas' Bluff, Georgia, due east of Fort Mitchell 40

6. Dark gray calcareous sand, pyritous, and con'aining nodular]masses 6 to 12 inches in diameter, with calcite nuclei. These nodules are arranged in strata about two feet apart, and terminate in an indurated stratum about 12 inches thick. Small fragments of lignite are scattered about through this stratum, and one or two large masses filled with calcitized teredos are found. The only other fossils seen were an *Anomia* and an *Exogyra*,—probably the young of *E. costata* (Say). The fossils are all poorly preserved. Dip at this point 40 feet to the mile southward.. 15 feet.
7. Gray sand of the same nature as the preceding, only no nodules were seen, and the shells increase in quantity, particularly in the lower part. The upper part of this stratum becomes more argillaceous and contains no fossils. Causes landslides in the banks like the Black Bluff clays, which they resemble somewhat physically. These sandy clays give rise to Uchee shoals.....100 feet.
8. Laminated dark gray clays with masses of yellow sand distributed at irregular intervals throughout this stratum, best developed just above the mouth of Uchee Creek, Alabama..... 25 feet.
9. Yellow and white sand with thin seams of lignitic sand, and an occasional "bunch" of gray laminated clay. These sands are exposed in a bluff about 100 yards from the river just below the mouth of Rooney's Mill Creek, Georgia..... 50 feet.
10. Quartzose conglomerate, much like that at Havana, Hale county, Alabama. From the shoal at Beden's Rock, and the bluff at Hatcher's Lower Landing, merges gradually into a yellow sand:..... 50 feet.
11. Yellow sands and gray clay containing bits of leaves. This stratum and the following are seen at Chimney Bluff, Georgia..... 60 feet.
12. Light yellow and white sands containing beds of well rounded quartzose pebbles, sometimes 20 feet thick, Lignitized logs seen protruding from the bluffs. The sands contain a small *Exogyra* at rare intervals. The supposed top of the Eutaw group..... 45 feet.

RIPLEY SERIES.

13. Gray sandy calcareous clay with lines of boulder-like concretions projecting from the bank; first seen at Lawson's wood-yard. Few fossils occur in the lower part of this stratum except *Exogyra costata*. A mile above Bluffton, Georgia, characteristic Ripley shells, mostly bivalves, are

found in a much decomposed state, throughout the stratum 6 to 8 feet thick. The uppermost ten feet of this stratum, highly fossiliferous. The river washes out little cave-like recesses in the banks. Near Jernigan Landing, Alabama, slight rolls in the strata are seen, involving about 20 feet of the sands ; these miniature anticlinals and synclinals continue to within two miles of Florence; the dip estimated from the line of boulders, averages about 20 feet to the mile, and is normal in direction..... 120 feet.

14. Two miles above Florence, and making a part of a bluff 50 feet high at that place, is a gray sand interlaminated with thin seams of a more argillaceous sand, all of which is unfossiliferous. Dip about 40 feet to the mile..... 26 feet.
15. Gray calcareous sand containing a small *Anomia*, and a line of hard rounded concretionary boulders..... 40 feet.
16. Gray and yellow sands resembling in physical characters, those of the Tertiary at Lower Peach Tree, Alabama..... 30 feet.
17. Gray highly fossiliferous marl; the fossils are nearly, if not quite, all bivalves, and are mostly comminuted as if they formed an ancient shore line. There are numerous sharks' teeth, a hard black substance in sections, resembling the under shell of a turtle, black coprolitic (?) pebbles, and fragments of lignite..... 3 feet.
18. Sandy stratum, indurated, and containing *Ostrea* sp. (?).. 1 foot.
19. Cross-bedded gray sands and clays..... 15 feet.
20. Fossiliferous marl about the same in character as 17; only little or no lignite was seen, the marl appearing to be somewhat glauconitic. (The strata from 17 to 21 inclusive, form a bluff on the east side, five miles below Florence)..... 2 feet.
21. Gray glauconitic calcareous sand, weathering into fucoidal masses, and containing a few soft white phosphate nodules..... 10 feet.
22. Gray fossiliferous marl, shells much decomposed. An occasional lignitized log, and numerous slightly phosphatic nodular masses, containing fossils, occur in this stratum.. 3 feet.
23. About the same in general character as 21, but contains indurated ledges about one foot thick, which show the dip to average about one foot to the mile, with numerous rolls; ends just above mouth of Cowikee creek... 170 feet.
24. Soft, less coherent sand, gray in color, appears at the mouth of Cowikee creek, where the south bank of this creek, composed of this strata, may be seen to rise 50 feet from the water..... 60 feet.

25. Gray calcareous sand with indurated edges, *Exogyra costata*, *Gryphæa mutabilis*, *Hamulus onyx*, *Plicatula urticosa*, *Anomia* (?), forms the shoal at Frances' bar and Bluff at Eufaula ..... 190 feet.
26. Light gray and yellow sands, interlaminated with sand darker in color, more argillaceous and containing bits of lignitized leaves and twigs; no other fossils seen; crops out in the gullies of Eufaula next below the drift ..... 20 feet.
27. A massive gray sand with a few fragile fossils and boulders. This sand is only slightly calcareous, and is more or less lignitic. Dip here about 150 feet to the mile... 40 feet.
28. A more calcareous sand filled with *Exogyra costata*, and many indurated ledges, giving rise to the first bar below Eufaula ..... 70 feet.
29. Light yellow cross-bedded sands between indurated ledges ..... 20 feet.
30. Calcareous *Exogyra* sands with boulders ..... 50 feet.
31. Yellow sands and indurated ledges filled with casts, *Exogyra costata*, and echinoderms set fast in the ledge. The sands are cross-bedded and contain some lignitic streaks ..... 35 feet.
32. Gray fossiliferous sands with boulders; the sand is massive and is fossil-bearing only in the lowest five feet... 40 feet.
33. Brown, laminated argillaceous sand; disappears at the mouth of Pataula creek, Georgia ..... 5 feet.
34. Light yellow sand and interstratified very irregularly with a gray micaceous sand filled with friable Ripley fossils. Mouth of Pataula creek ..... 30 feet.
35. Hard sandy ledge, weathered surface jagged, contains *Exogyra costata* and echinoids; very light yellow in color, white when dry and unweathered ..... 30 feet.
36. Gray sand with indurated ledges; no fossils seen; merges gradually in the upper part into a dark, almost black sand containing large nodular masses, and interstratified with light yellow sands ..... 35 feet.
37. White coarse conglomerate, the matrix material being calcareous. The quartzose pebbles decrease in size towards the top and the stratum becomes more argillaceous; ther are many casts, but all too obscure for identification ..... 18 feet.
38. Massive blue clay; contains a few bits of teredo-eaten lignite (probably the top of the Cretaceous) ..... 6 feet.

MIDWAY OR CLAYTON SERIES.

39. Massive sandstone, coarse grained and almost a conglomerate..... 8 feet.
40. Light yellow siliceous limestone, containing a large *Ostrea* and numerous obscure casts. Five miles above Fort Gaines, Georgia..... 10 feet.
41. White calcareous sand, containing a few obscure casts and Ostreas. The sand sometimes becomes irregularly indurated, and is the source of small lime springs. Forms the lowest part of the bluff at Fort Gaines, Georgia, and in its uppermost ten feet contains pockets of white sand enclosed by black clay, the clay resting in "pot-holes" in the limestone. Estimated at 200 feet.

NANAFALIA SERIES.

42. Glauconitic sand filled with *Gryphæa thirsæ*, *Ven. planicosta* and *Crassatella*.....6 to 12 feet.
43. Gray calcareous sandy clay containing boulders of clay and a few decomposed *Gr. thirsæ*..... 15 feet.
44. White and lignitic and cross-bedded sands, and sandy gray clay, containing one or two ledges of pseudo-buhrstone..... 50 feet.
45. Dark gray argillaceous sand, with new fossils and fragments of water-worn clay balls. The lower part becomes more fossiliferous, containing *Osteodes caulifera*, *Ven. planicosta* and *Gr. thirsæ*..... 6 feet.
46. Greenish gray, fine grained calcareous sand, very firm and holding decomposed shells, mainly bivalves..... 6 feet.
47. Coarse glauconitic sand, filled with large *Ostrea compressirostra*, *Ven. plenicosta*, and a small *Pecten* resemblingthe species occurring at Yellow Bluff on the Alabama river..... 3 feet.
48. Cross-bedded sands, yellow; the bedding planes being marked by streaks of gray clay..... 10 feet.
49. Yellow and gray sandy clays, containiug occasional beds of *O. compressirostra* and *Gr. thirsæ*. The indurated ledges which sometimes occur, seldom over two feet thick, are of the nature of pseudo-buhrstones, and are filled with bivalves; the only exception being *T. mortoni* (large). This disappears below the surface at the mouth of the first large creek flowing from the Georgia side, below Fort Gaines..... 75 feet.

TUSCAHOMA (OR BELL'S LANDING) SERIES.

50. Light yellow and gray sandy clays, containing, in the sandier portion, boulders much like those seen at Bell's Landing. No fossils seen. These are undoubtedly the lower Peach Tree clays and sands. They become more sandy on ascending..... 170 feet.
51. Light greenish yellow sands, filled with bits of decomposed shell and large *O. compressirostra* and *Ven. planicosta*..... 3 feet.

An interval of fifty yards and then,

BASHI (OR WOOD'S BLUFF) SERIES.

52. Gray sand filled with decomposed fossils. An irregular indurated ledge (non-fossiliferous) occurs in this stratum. This is probably Bashi, though the only fossil that could be determined with any degree of accuracy, is the small oyster so common at the typical locality..... 18 feet.
53. Blue clay, slightly sandy..... 6 feet.
54. Light yellow siliceous (sandy) limestone, filled with casts and containing pockets of *O. compressirostra*..... 18 feet.

HATCHETIGBEE SERIES.

55. Gray lignitic sandy clay (Hatchetigbee)..... 10 feet.

BUHRSTONE SERIES.

56. Coarse white sand, containing *O. divaricata*, and a few other friable shells in the upper part..... 12 feet.
57. Buhrstone, the first flexures since leaving Eufaula occur in the stratum. Rather sandy..... 40 feet.
58. Light yellowish green sand, containing numbers of small *O. sellæformis*..... 45 feet.
59. Buhrstone..... 55 feet.
60. Greenish yellow calcareous clay, with a few decomposed fossils, and an occasional large *O. sellæformis*..... 12 feet.

CLAIBORNE SERIES.

61. White sandy limestone with small *O. sellæformis* in abundance, and pockets of larger sized shells. Makes capping ledge to island at mouth of Omussee creek, where the bluff is about twenty feet high. This stratum is made up of alternate beds of hard and soft strata; all containing more or less of *O. sellæformis*. The harder strata weather out into root-like shapes, and are sometimes rather argillaceous. Many return dips occur in this stratum, stringing it along the banks for many miles further than it would be normally.

The dips are all steep both ways, and many gaps in the succession are caused by the washing out of the softer beds. Owing to these gaps and return dips it is rather hard to estimate the thickness of the stratum with much accuracy. It dips below the surface of the river, two miles below Gordon, Alabama, and is last seen on the Georgia bank. At Gordon there is a very pronounced return dip, estimated at, and not exceeding..... 60 feet.

WHITE LIMESTONE SERIES.

62. The *Scutella* bed, from the beginning, weathers so as to make it not possible to count up its thickness. It is literally full of fossils; mainly *Scutella Lyelli* and *Pecten nuperus*, with a few smaller and thicker Scutellæ. A bluff about twenty feet high occurs oposite the mouth of Sowhatchee creek, Ga.....25 to 30 feet.

63. White orbitoidal limestone, seen first at Dougherty's Wood Yard, Georgia, and on the Alabama side, nine miles by river from Neal's Landing. This limestone contains numbers of echinoids about five miles above Neal's. The limestone continues as far as Miriam's Landing, at which place the thickness is..... 200 feet.

CHATTAHOOCHEE SERIES.

64. Argillaceous and sandy limestone, alternating with strata of purer character. Contains a *Pecten* and an *Ostræa* very close to our recent Virginica. This may be termed the Chattahoochee group, as it is well developed there and along the eastern river bank, for the next ten miles..... 25 feet.

ALUM BLUFF SERIES.

65. Light yellow sand, containing pockets of fossils. Where there are no shells, the sand is very calcareous. Fossils resemble those described by Conrad, as Miocene from York county Virginia, and Maryland.. ..... 35 feet.

66. Gray sand, slightly calcareous..... 5 feet.

67. Gray calcareous sand filled with shells. The leading fossil is a Mactra.....10 to 15 feet.

68. Black lignitic sand. This contains much pyrites, and from the efflorescence of ferrous sulphate arises the name Alum Bluff. Varies with the preceding...10 to 15 feet.

CHAPTER XII.

GEOLOGICAL SYSTEMS IN POLK COUNTY.

INTRODUCTION.

[NOTE.—A GEOLOGICAL MAP OF POLK COUNTY HAS BEEN PREPARED. FACILITIES FOR ITS PUBLICATION ALONG WITH THE PRESENT REPORT HAVE NOT OBTAINED.]

Extending across the northwestern part of the State, there is a large belt of country occupied by stratified rocks, although disturbed and in places metamorphosed, belonging to the Palæozoic group. This area forms a natural division for geological exploration. Polk county was chosen as the district for commencing the survey of this division, as it is situated upon the border of the State, and is traversed by the boundary line between the Palæozoic formations and the metamorphic rocks.

From the economical standpoint, this county is of no less importance than from the scientific, for in it there are vast deposits of brown iron ore, limestone, slate, etc., as well as rich agricultural lands.

But the relationship of these useful minerals, to the rock systems of the country, can only be made intelligible after a consideration of the characteristics and distribution of the geological formations occupying the county.

The geological formations of Polk county are all disturbed and thrown out of their original positions, thus producing many complications. The rock materials are generally decayed, so as to leave upon their surfaces only skeletons of their primitive conditions. Under such circumstances, it is necessary to draw more or less of our information from beyond the boundary of the county, in order to ascertain the geological relationship of the formations which are found therein. Without waiting for the time when the detailed knowledge of the geological structure of the Palæozoic formations of Northwest Georgia shall be ready for publication, it is necessary to anticipate and briefly present the position which Polk county holds in relation to the rock systems of the country.

The great geological groups are, in descending order:

Groups.	*Systems.*
CENOZOIC.	Modern. Pleistocene. Pliocene. Miocene. Eocene.
MESOZOIC.	Cretaceous. Jurassic. Triassic.
PALÆOZOIC.	Permian. Carboniferous. Devonian. Silurian. Cambro-Silurian or Ordivician. Cambrian.
ARCHÆAN.	.....

The southern margin of Polk county is occupied by semi-metamorphic rocks of uncertain age. All the other formations of the county belong to the Palæozoic group, and almost entirely to the Cambro Silurian system, with a limited area assigned to the Cambrian, and smaller developments to the base of the Devonian and Sub-Carboniferous systems.

The subdivisions of these systems, which occur in Polk county, can be better understood from the following table, in descending order:

Systems.	*Series.*
CARBONIFEROUS.	Lower or Sub-Carboniferous (Ft. Payne Chert, Hayes.)
DEVONIAN.	Oriskany?
SILURIAN.	Wanting.
CAMBRO-SILURIAN OR ORDIVICIAN.	Nashville Slates and Maclurea limestone (Safford), or the Chickamauga limestones and Rockmart Slates. (Hayes.) Knox Dolomite. (Safford.)

CAMBRIAN.	Knox Shales (Safford), or Connasauga Shales. (Hayes.)
	Knox Sandstone and Chilhowee sandstone (Safford), or Rome sandstone and Weisner quartzite. (Hayes.)
ARCHÆAN.	Doubtful.

The scientific consideration of these formations must be postponed until all the observations bearing upon them in Northwest Georgia shall have been made; consequeutly only their modes of occurrence in Polk county, compared with the typical localities, will be considered in their proper places.

CHAPTER XIII.

THE PHYSICAL FEATURES OF POLK COUNTY.

The topography of Polk county presents a variety of features, from bold mountains to rolling plains or valley lands. The general altitude of the country varies between 850 and 1,000 feet above the sea, with only limited ridges rising higher, except along parts of Dug Down Mountain, near the southern margin of the county, which rises to between 1,200 and 1,400 feet. This range of high lands forms a characteristic feature, extending in a line, convex towards the south, across the southern part of the county, from south of Esom Hill, near the Alabama boundary, to the eastern border of the county, southeast of Rockmart. The name, however, was originally applied to the central portion of the range, near the Dug Down Gap.

The boldest feature is upon the western border of the county, where Indian Mountain is situated on both sides of the State line. It rises to an elevation of 1,800 feet in Georgia, and reaches its maximum height of 1,982 feet, about a mile beyond the State line. Hence, it forms a feature rising a thousand feet above the valley to the eastward. From the foot of Indian Mountain, there is a chain of valleys extending north-northeastward to Floyd county, bounded on the east side by ridges rising two or three hundred feet above it. In the central portion of the county, the undulations are broader with the ridges subordinate to the general features. The eastern part of the county becomes characterized by more pronounced ridges. Most of the valleys which traverse the county can scarcely be considered as due to the erosive action of the rivers, for these flow through broad plains in shallow courses, which have not cut channels for themselves deeper than the required wants of the modern streams. In short, the streams are all flowing at the surface and without alluvial plains; yet the country, between the ridges or rolling highlands, is often broad. The valleys between the ridges also show their independence of the existing streams. Still, everywhere, there are the marks of great antiquity stamped upon the physical features of Polk county in spite of the youthful appearance of the water courses, for all the rocky prominences are generally removed from the higher lands, which are weathered into rounded outlines. The principal exceptions to this statement are found in the bold quartzitic cliffs of Indian Mountain, and in the limestone and slaty ridges in the Rock-

mart district. The slaty rocks also appear along the slopes of Dug Down Mountain, but the features are not so bold in as the other localities named.

Many of the ancient valleys have, to a greater or less extent, resulted from the mountain movements, which have brought the ridges into prominence. But all of these outlines have been greatly softened down by atmospheric agents, and the base line of river erosion appears to have been reached in ancient times. The subsequent changes of elevation, in this region, has not disturbed the equilibrium so as to allow the rivers to cut down their beds into deeper channels.

As the small streams emerge from the Dug Down Mountain range and Indian Mountain, there is an exception to the last statement in regard to the deepening of the channels. These streams are excavating insignificant *canons* and flow over rapids or successions of low falls. But, in such positions, all the streams are small, being near their sources, with water, generally free from menchanical sediments, flowing over the durable although slaty and schistose rocks. .

No large streams cut across any of the greater ranges or ridges in Polk county. The county itself forms an amphitheatre, or basin, closed in on three sides, with numerous streams rising upon their borders and flowing northward. These water veins gather up the drainage into three arteries: Cedar creek, flowing through the western portion of the county to join the Coosa river; the branches of Fish creek, in the central portion; and those of Camp creek, farther eastward, uniting to form the head-waters of Euharlee creek, which carries off the drainage of the eastern area to the Etowah river.

The variable, stony and clayey surfaces of the ridges, the slaty or loamy character of the lower lands, and the limestones along the streams, form features of topographic variation and importance, all of which are dependent upon the geological structure and are of particular importance, both from agricultural and mining standpoints; hence, their consideration will be delayed for later pages of this report.

CHAPTER XIV.

GEOLOGICAL STRUCTURE OF POLK COUNTY.

THE METAMORPHIC ROCKS.

From the southwestward, a zone of certain metamorphic rocks, extends into the county, for a width of only a few hundred yards, near Dug Down Gap; but it increases both westward and eastward to a breadth of three or four miles. These rocks are sharply defined upon their northern side: (a) they form a mountain rising two or three hundred feet in height and facing the lower lands to the north; (b) the rocks of this range are faulted or displaced, being brought to the surface and overthrust upon the rocks north of the great line of fault, which forms its northern boundary; and (c) the character of the rocks is distinct, being composed of hydromica schists of variable texture, but the pearly hydromica appears in more or less shining scales, whether of silvery gray or greenish color.

The fault structure is illustrated in the diagram, 'in which the letter N represents the metemorphic range and P the formations resting against and upon the northern side.'

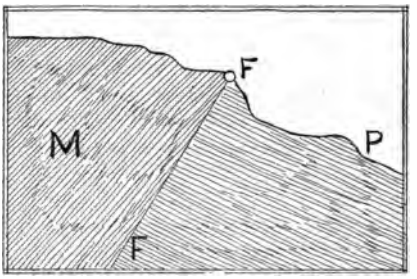


FIGURE 12.

At various points, along the Dug Down Mountain range, the rocks are found to dip at different angles. Near Hightower Mill, the dip is nearly forty degrees in direction S 80° E. Farther eastward, at Simpson's Mills, the dip is lessened to 20° or 25°, and in direction between S 30° and S 50° E. A few miles westward, at Brown's Gap, the rocks also dip at comparatively low angles toward the south. In several places, north of the fault line, the rock formations were

observed to dip at angles much greater than those of the metamorphic range, as near Simpson's Mills.

The hydromica schists are composed of admixtures of the minerals of the hydromica group and grains of quartz. The hydromicas vary greatly in composition, but they are essentially hydrous alkaline silicates of aluminium. They are characterized by their greasy feel and pearly lustre, and are apt to occur in laminæ cleaving into mica-like scales.

These hydromica schists are often compact and in thick layers, but easily cleave into rough slabs, or occasionally into smooth slaty-like plates. Sometimes the quartz predominates, in which case the rock is harder than usual. Quartz veins often traverse the rocks, and are frequently parallel to the bedding. Although, everywhere in the county, these rocks are more or less chemically decayed yet they resist degredation and are not readily removed by meteoric agents. The broken schists are usually covered with only thin layers of soil, upon which angular quartz gravel and blocks, derived from the more quartzose layers of the disintegrated schists are often scattered. These hydromica schists form extensive deposits in the State, and their general character and position are subjects of greater consideration than is due their narrow developments in Polk county. They are only semi-metamorphic, and are less highly altered than the mica schists and other rocks farther southward. The information derived from Polk county does not settle their age. Whilst they are younger than the typical Archæan rocks of Georgia, they cannot be placed as the upper members of that group, for it is quite possible that they belong to some portion of the Palæozoic system. Yet they constitute a distinctive feature in the geology of the county, having been overthrust and brought into contact with the various Palæozoic formations immediately north of the fault line, which sharply defines their northern boundary. This fault line was an oblique thrust, which has been traced across Georgia into Tennessee, by Mr. C. Willard Hayes, of the United States Geological Survey,* and which he estimates, to have reached the enormous throw of eleven miles, in one locality—that is to say, there has been a lateral slipping or narrowing of the earth's crust to the extent of eleven miles, where the strata of one zone have been piled on top of those of the adjacent country. Such distortions have added greatly to the difficulties of the geological problems.

As already pointed out, these metamorphic rocks have given rise to a low mountain range, and to the light slaty lands covered with thin soils.

* "The Overthrust Faults in the Southern Appalachians." Bull. Geol. Soc. Am., Vol. II., p. 141, 1890.

CHAPTER XV.

THE CAMBRIAN SYSTEM.

In the northwestern portion of the county, the East Tennessee, Virginia and Georgia Railway passes through a succession of valleys, which mark the boundary between the Cambrian formations and those of the Ordivician system. From the State line, near Etna, for a distance of five or six miles, the narrow valley sharply defines the clayey ridges of the Knox Dolomite formations, on the east, from the slaty Cambrian ridges, on the west. A considerable portion of the valley is underlaid by slate, which rises up into low ridges, covered with a thin capping of soil. Near the surface, the slate is of a drab color, but at greater depths it becomes darker. In texture, it is fine grained and cleaves into thin plates. The dip is at angles of about 20° and in direction S. 40° E. West of these lower slate ridges, others rise, to be succeeded by the *massif* of Indian Mountain, which reaches an elevation of 1,100 feet above the valley. The lower ridges of the mountain are composed of hard slates, with occasional beds of quartzitic sandstone, often several feet thick. The upper portion of the mountain is composed of light, but occasionally dark, colored beds of compact quartzitic sandstone, sometimes approaching the structure of conglomerate. These beds are very thick and form bold cliffs. The strata dip at angles from 40° to 50° towards S. 30° to E. The northern end of the mountain is abruptly cut off and succeeded by strata belonging to the next formation, which thus appears out of its natural position.

A characteristic feature of the Knox shales is the occurrence of intercalated beds of dark blue limestone, which is often oolitic. If these beds are not found in Polk county, they may be seen just north of it.

In these deposits, just described, there are the representatives of three of the divisions of Prof. Safford's classification in Tennessee, namely: the Chilhowee sandstone, forming the *massif* of Indian Mountain, overlaid upon its flanks and lower ridges by the Knox sandstone formations (shales and bedded sandstones), and finally by the Knox shales, occupying the eastern ridges and passing down so as to make the valley at Etna, Pryor, etc. Beyond the limits of Georgia, the Chilhowee sandstones are noted for making bold isolated mountain knobs.

The thickness of these Cambrian formations is very great. Prof. Safford estimated the Chilhowee sandstone formation, in Tennessee, at not less than 2,000 feet, the Knox sandstones at 800 or 1,000 feet, and the shales at from 1,500 to 2,000 feet. Mr. Hayes' estimate of these deposits differs only in making a greater variation of thickness of the first two formations, which together he places at from 2,000 to 3,500 feet, and gives the same estimate for the shales as Prof. Safford. The maximum thickness, here given, is probably too low; judging from the formations of the Indian Mountain group.

As before stated, the formations of Indian Mountain are abruptly cut off by a transverse fault. But spurs of Cambrian rocks extend southward from Cave Spring, and enter Polk county upon the eastern side of an embayment of the Knox Dolomite series, as will show on the map when published.

In these thick deposits of mechanical sediments, no fossils have so far been found in Georgia. But supposed worm burrows (*Scolithus*), and forms of sea-weeds occur upon the surfaces of some of the beds in Tennessee.

CHAPTER XVI.

THE CAMBRO-SILURIAN OR ORDIVICIAN SYSTEM.

KNOX DOLOMITE SERIES.

This formation occupies by far the greater portion of Polk county: except the limited Cambrian mass which obtains in the northwestern part; an area southwest of Cedartown, covered with younger deposits; another along the headwaters of Fish creek; and a third district in the part of the county, north, east and south of Rockmart, where younger formations overlie the Knox Dolomite.

Where exposed in an undecayed condition, the formation is foun to be composed of dolomite or magnesian limestone, and some beds of, ordinary limestone. In the middle and upper portion of the series, chert abounds, and occasionally it is found in quantities sufficient to form beds of flinty sandstone. It is from the chert of the upper beds of the Knox Dolomite that the flinty gravel, which covers many of the ridges, is derived. Where preserved, rocks have been found to contain a sufficient number of fossils to identify their position in the geological scale. Stratigraphically, they are found to overlie the shales of the last system.

From investigation of these rocks in Polk county alone, the character of the Knox Dolomite series could not be determined; for they are decayed to great depths wherever examined, thus destroying their lithological structure and organic remains. But the distribution can be determined from the position of their skeleton remains, and the strata of contiguous formations. The observer rarely sees the pure limestone and dolomitic beds, except when brought to the surface from deep wells. Ordinarily, the only rocky masses exposed are beds of cherty sandstone (sometimes ferruginous). But many of the ridges are covered with flinty gravel derived from the smaller fragments arising from the decay of the limestones and dolomites, which have everywhere had their calcareous matter dissolved and washed out by rain waters and springs, thus leaving only such clay and sand impurities as existed in the original rock, and the concretionary cherty masses contained therein. Thus, we find the county covered with residual clays derived from the decay of the calcareous rocks. These residual clays, however, present striking variations. From the more calcareous and less siliceous

limestone, the red clays of the valleys, and some of the hills, were formed. From the more siliceous deposits, especially of the upper portions of the Knox series, the light, sandy clays, commonly covered with loose, superficial, flinty gravel, have been derived. Again throughout the mass, there are irregular pockets of white and purple clays, which are best exposed in the ore diggings or banks.

Wherever the bedding is preserved, we find that the strata have been much disturbed from their original positions, and dip at various angles; thus, fragmentary deposit at one of the Etna mines shows a considerable dip to the northeast. In the railway cut, at Oredell, the dip, at variable angles, has a general direction of north 15° west. But the formation more commonly dips to the southeast. In the country occupied by the Knox Dolomite cherty ridges and valleys, the topographic differences vary with the disturbances of the beds, and the presence of the original pure limestones or more cherty upper beds. Thus the topography appears more rugged in the northwestern part of the county than in the southern and central portions. The gray residuary clays abound in the northern part of the county, whilst in the southern portion, there is a great amount of red clay.

The Knox Dolomite series abuts against the metamorphic rocks of Dug Down Mountain in several places.

Numerous wells, to 60 or 90 feet in depth, are excavated out of residual clays of this formation, and an artesian well sunk at Oredell indicates decayed cond tions to a depth of 180 feet.

The Knox formation passes beneath the limestones of the next horizon, exposed along the upper branches of Cedar and Fish creeks, and also along of Camp creek, of the Rockmart district. This formation is the great brown ore horizon to be noted later.

From the decayed character of the surface, and from the absence of sufficient rock exposures, it is impossible to estimate the thickness in Polk county, except that it must be very great, as there is a broad extent of country occupied by these formations, which dip at considerable angles; but we do not know to what extent this inclination is reduced by undulations of the strata. In Tennessee, Prof. Safford places the thickness at 4,000 feet, and it appears to be equally thick in Georgia.

CHAPTER XVII.

MACLUREA LIMESTONE SERIES.

In the vicinity of Cedartown, and southwestward; along the upper waters of Fish creek; and in the Rockmart district, the Knox formation is overlaid by massive blue limestones, in color varying from light gray to dark, with a semi-crystalline texture, and slightly metamorphosed. The rocks are best exposed along the streams which flow over them, and in the vicinity of which they frequently outcrop in the valleys. It is only in the eastern part of the county, at Rockmart and beyond, that the rocks rise in bold ridgelets. The undulating strata frequently lie at low angles, although sometimes dipping steeply, and showing occasional anticlinicals. Thus, at the springs in Cedartown, they dip at 5° to 10°, in direction N. 20° W., but on the south side of the town, there is an anticlinial, at the bridge over Tanyard branch. The dip of the beds on the eastern side is 10° or less, in direction N. 70° or 80° E., whilst on the western side, the dip decreases from 45° to 15°, in direction N. 80°. W. However, the beds generally lie at low angles. In the eastern part of the county, they commonly dip at angles of about 20° towards S. 40°-50° E.

These limestones are generally valley making. In their decay, the weathering is upon the surface and does not penetrate the mass, and hence we do not find the limestone in a decomposing condition, but sharply defined from the overlying residual clays, left after the solution of the calcareous matter. These clays frequently form fertile valley lands.

When these limestones form ridges they are frequently traversed by caverns.

The rock is of the pure limestone type. That at Cedartown yielded the following analysis to Mr. W. J. Land (for the Cherokee Iron Company in 1878):

Calcium carbonate	94.37 per cent.
Magnesium carbonate	2.10 per cent.
Alumina	2.23 per cent.
Undetermined	1.30 per cent.

The limestone from the great quarry at Devitte, five miles northeast

of Rockmart, gave the following analysis in 1884 (Cherokee Iron Company):

Calcium Carbonate	95.203 per cent.
Magnesium carbonate	2.171 per cent.
Alumina and iron	0.400 per cent.
Insoluble matter	2.300 per cent.

The limestones usually occur in beds many feet in thickness, of compact texture with rarely jointed structure. Indeed, the rocks are slightly crystalline and pass beneath the semimetamorphic Rockmart slates. No fossils have been found in these limestones, whose original structure has been rendered crystalline; but their position has been recognized as identical with the Maclurea horizon of Tennessee.

The thickness of the limestones in Polk county reaches several hundred feet, but the data for the exact determination has not been obtained. The thickness is probably equal to that in Tennessee, which Safford has estimated at 600 feet.

From the fossils found by Professor Safford, the geological horizon of the Maclurea limestones has been correlated with the lower portion of the Trenton division of the Cambro-Silurian system.

IRON-LIMESTONE SUB SERIES (SAFFORD.)

Northeast of Rockmart, and extending for about seven miles, there is a chain of isolated exposures of thin bedded ferruginous limestones, lying unconformably upon the Maclurea limestones, and near the geographical margin of the succeeding Rockmart slates. The rocks are so decayed as to leave scarcely more than laminations of yellow and brown iron ore or ochre. These beds are well shown at the ore pits of the Central Mining Company, about four miles northeast at Rockmart, and at Deaton Mine, a few miles beyond. At the former locality, the ferruginous beds are twenty feet or more in thickness without exposing their full depth. They rest upon a small anticlinal of Maclurea limestone, which trends northeast and southwestward. The iron limestones dip at angles of ten to twenty-five degrees. The individual beds vary in thickness from two to ten inches. Some of the upper beds, as well as certain intercalations, now consist of ferruginated residuary clays, as all the calcareous matter has been removed. These form ochres.

At Deaton Mine, these ferruginous beds rest upon Maclurea limestones, which have been rendered cavernous, in places, beneath a roof of the iron limestone series. This weak roof has subsequently collapsed and filled the chambers with a heterogeneous mass of ore.

The iron bearing series has a thickness perhaps reaching one to two hundred feet. The formation probably passes beneath the slate beds to the southeast. These ore beds will be referred to again.

CHAPTER XVIII.

NASHVILLE (OR ROCKMART) SLATE.

The greater portion of the basins of the Maclurea limestone, in Polk county, are overlaid by the slates of this series, whose areas are fringed by the earlier limestones. Accordingly, there are three basins of these rocks in the county—Cedar creek, Fish creek and Rockmart districts, the eastern having the most rugged and boldest features.

The slates appear to occupy synclinal troughs or folds, and also appear to be somewhat faulted, as they occupy basins upon the limestones, yet are generally seen to dip at considerable angles towards the southeast. Near their junction with a metamorphic belt of Dug Down Mountain, the slates are at very high angles, whilst near Devitte, unconformably overlying the limestones, they dip at only twenty-five degrees. In some of the ridges—as at the slate quarries of Rockmart, in a ridge rising over one hundred feet above the valley, the beds dip at 45 degrees and more towards the southeast, and are obliquely jointed.

Beyond Rockmart ,the slate beds appear to be considerably dislocated, thus allowing the older formations to come to the surface, and constituting the broken but more picturesque topography of the county. The shales or slates present a yellowish gray weathered surface, but have a bluer color where less exposed. In some places, in the Rockmart districts, these weathered shales are of a yellow-brown color. Some of the lower beds are composed of fine dark and black slates. In places, these rocks are intercalated with a metamorphic compact conglomerate, containing slaty fragments; such is seen on the road between Rockmart and Simpson's Mills. In Polk county, the rocks all appear to be metamorphic or semi-metamorphic, with the obliteration of such fossils as have been found elsewhere in the formation.

The thickness of the formation in Polk county equals that of Tennessee, or 2,000 feet or more.

CHAPTER XIX.

DEVONIAN AND CARBONIFEROUS SYSTEMS.

ORISKANY (?) SERIES.

A small outlying patch of quartzite succeeds the Nashville slates, about four miles southeast of Esom Hill, near the fault line, at the foot of Dug Down Mountain. These rocks are provisionally classified as Oriskany.

LOWER OR SUB-CARBONIFEROUS SERIES.

The Fort Payne series of chert, of Mr. Hayes, succeeds the slate beds on several ridges southwest of Cedartown. These ridges are covered with cherty blocks and fragments with which iron ores are often associated. On the northwestern side of the most southern ridge (Mr. West's farm), the chert form sandstone beds, which are ferruginous in part. These iron ores will be noticed later.

MODERN DEPOSITS.

Except the continued action of the weathering of the older rocks the creeping down the hillsides of decomposed material, and the occasional deposits, in swampy ground (which is rare); no modern formations can be considered as occurring in the county, for the rivers are not flowing through such lands as would permit of bottom formations. Still there are a few places where the streams overflow basins through which they pass.

CHAPTER XX.

MINERAL RESOURCES OF POLK COUNTY.

IRON ORES.

The aggregate amount of iron ore in Polk county is very large, of excellent quality, and with favorable conditions for mining operations. There are four principal districts, where the ore is now obtained: namely, the East Tennessee Railway district, in the western part of the county; the Cedartown and Camp creek districts, in the central part; and the Rockmart discrict, in the eastern. But within this geographical distribution, and in other localities, the ore occurs under very different conditions.

KINDS OF ORE.

All the important iron deposits of Polk county belong to the brown ore and limonite varieties.

Pure limonite consists of two varieties. The one is massive, having a globular or botryoidal form, with an interior fibrous structure. The other kind is earthy and massive. The color of the first variety is often rich brown and dark, with frequently a metallic lustre. The color of the latter kind is ochre or brownish yellow with an earthy appearance. The color of the powder in both cases is dull yellow, or yellowish brown. The first variety is hard (5-5.5), whilst the latter is soft. The specific gravity varies from 3.5 to 4. In composition, it is a hydrous sesquioxide of iron, containing when pure: iron, 59.92; oxygen, 15.68; water, 14.40. The percentage of iron falls short, owing to impurities commonly mixed with the mineral. But on the other hand, limonite is apt to lose water, and to graduate into an admixture of itself and hematite, which latter may contain 70 per cent. of the metal. Such is the condition of most of the brown ore of Polk county, often containing not more than two or three per cent. of water. The brown ore always contains some admixture of clay and sand. The percentage of other impurities, such as phosphorus, which is deleterious, is usually small, and does not make up an important volume of the mass. Whilst such is the general composition of brown ores, they vary much in physical appearance with the geological formations, from which they are derived.

There are three distinct geological horizons, in Polk county, which contain brown ores. The greatest volume of the ore occurs in the Knox dolomite formations; some of the most valuable ore occurs in the Iron-Limestone division, above the Maclurea division; and other deposits are associated with the Lower Carboniferous chert beds.

THE ORES OF THE KNOX DOLOMITE FORMATION.

The ores associated with the Knox Dolomite formation have been derived from the weathering of those rocks, whereby the calcareous matter has been leached out. By this process, when the rocks consist of the purer limestone and dolomite, there remains only clay, and the iron ore, which was originally in the form of the carbonate or the sulphide. Under these conditions, we find that the ancient limestones have given rise to valleys and subordinate ridges, whose degradation has been checked by the enduring accumulation of the ferruginous gravel and boulders. The more siliceous beds, after the calcareous matter has been leached out, leave prominent ridges of clay and sandy earths, commonly covered with chert, and some unimportant deposits of brown ore. Such, especially arise, from the decay of the cherty layers of the higher beds of the Knox formation. Accordingly, it is from the more calcareous beds that the greater volume of the ore was derived. As might be expected, the red presence of the iron has left evidence of itself, which has colored most of the ore bearing hills, a contrast to the gray cherty ridges, although the former contain numerous "horses" or pockets of clay of white or light purple color.

The red banks, which contain ore in greatest quantities, are most commonly situated near the border of different geological formations: or where the geologically lower and more feruginous beds of the Knox series appear at the surface; owing to either erosion or to their repetition by geological faults. This holds true, whether the more ferruginous beds pass under the overlying Silurian rocks or not, for the accumulation of iron has largely resulted from concentration occasioned by the removal of calcareous matter from the original rocks—this action only taking place when they are exposed to surface weathering. Hence, the great economical importance of knowing not merely the horizon of the ores, but also of the mapping of the boundaries of the districts occupied by each formation. Thus, in the western part of the county, the deposits of Etna, Oredell and other places, near the junction of the Knox formation with the underlying Cambrian formation, is characterized by valuable ore deposits. With Cedartown, as a focus, there is a parabolic curve of ore deposits extending southward. There is a similar occurrence in the Fish creek district, and again northwestward of Rockmart. All of these ore ridges belong to the

Knox dolomite, and are within comparatively short distance of the valley making and overlying Maclurea limestone, as shown on the map. This distribution is accordingly adjacent to the valleys and embayments, which appear to have been the most favorable conditions for the accumulation or concentration of the iron. Upon all the ridges, even those covered with chert, more or less important deposits of ore are liable to be found.

The physical condition of the ore deposits is variable. They occur in small concretionary masses and grains—"wash-ore"—throughout the clay; and in masses from large concretionary boulders, in some cases, to great irregular pockets, almost assuming the form of beds. Again, they occur in irregular beds, but when such is the case, its value is greatly reduced, as they are usually only richly ferruginous chert of too low grade for profit. The wash-ore and the massive boulders are, more or less, accumulated into irregular pockets interrupted by clay "horses," beneath which the ore banks or pits are not often opened. Sometimes, however, these deposits of ore are in the form of great irregular beds, and may be seen passing beneath the "horses," as in an old ore-digging near Oredell.

On some of the red hills, the presence of the ore is indicated by ferruginous gravel or blocks, strewn upon the surface. Sometimes its presence is only indicated by the red clay. The superficial covering of the ore may vary from a few inches to several feet in thickess, and contains enough iron pebbles to repay its removal, when washers are used. In the richer part of the deposits, the appearance to the unpracticed eye, is not always promising, but yet the accumulation may prove rich enough for the separation of the ore to be made by the more extravagant method of screening; when it sometimes happens that even three or four tons of clayey matter can be removed for one of ore obtained. But when the ore is washed, it is usual to work over all the superficial dirt, and a very small percentage of iron can thus be concentrated with a good resulting product. In the case of massive ores a larger per cent. of available mineral is necessary to cover increased cost of operation.

THE ORES IN THE VALLEY OF THE E. T., V. & G. RAILWAY.

Continuations of the ore ridges of Alabama cross into Polk county, at Etna, and extend northeastward, as a chain of ridges along the eastern side of the valley, upon whose western side there are slate ridges. The mines upon the State line contain the most massive deposits of brown ore seen. In these workings, apparent bedding was observed in a disturbed condition, almost as if there had been some great lime-sink into which the roof of a former cavern had fallen, in heterogeneous masses. The ore has a different physical

appearance from that of the Cedartown district, having a more massive and less concretionary form, in which are conspicuous fragments of decayed flinty matter. Upon the supposed Alabama side of this deposit, the ore has been worked to a depth of sixty or seventy feet without reaching its base. On the Georgia side the workings have not reached such a depth.

From Etna, a chain of pits continues northeastward to Wood's and other banks near Pryor. Farther northward, there is a large assemblage of banks at Oredell. Near this point there are contact disturbances between the different geological formations. Some of the extensive ore banks at Oredell are typically like the general red banks of the Knox series; but again, others are more less connected with chert beds, which cover many of the ridges. Some of these ore banks are very extensive. In boring for an artesian well at Oredell, a development of one hundred and eighty feet of ore deposit was found beneath the bottom of the valley. A little beyond Oredell, the geological disturbances dislocated the formations, but after a gap of about two miles, the chain of deposits continues to near the northern county line, upon the eastern side of the railway. On the western side of the railroad, there is a basin of Knox Dolomite thrown westward between the ridges of Cambrian rocks into a trough about two miles westward of "Hematite" Siding. In this norrow basin, there are valuable ores of usual type, and also siliceous deposits. In one place, the ore was found lying beneath a clay "horse." Some of the siliceous ore might be regarded as extensive ferruginous cherty beds. There are also found iron-manganese ores. The "Hematite" (Linton Spark's) and the Stot Folger ore deposits embrace the principal iron beds exposed here.

ORES IN THE CEDARTOWN DISTRICT.

These very extensive ore banks usually occur upon subordinate ridges, rarely rising to one hundred feet above the valley. They occur adjacent to the boundary of the Maclurea limestone, forming the valley. Such is the position of the disconnected ore ridges, which are extensively found around the margin of the newer limestone formation. The largest workings are those situated two or three miles westward and southward of Cedartown, and constitute a chain of ore banks, as for instance, the Reed, Ledbetter, Peek and Wood mines.

The relative amount of the ore and the prevalence of "horses" vary in importance. The ore is known to have a depth of not less than forty feet in some places. It is mostly composed of fine concretionary material or "wash ore," with only a moderate quantity of massive blocks. In one part of the Peek mine, the ore approaches the appearance of bedding, and near by, there is an exposure of ferruginous chert, forming an extensive bed or cliff. In some cases,

these hills are covered with ferruginous gravel; in others the surfaces are covered with red clay containing fine concretionary ore, which is sufficient to justify the washing of the mass.

Southwest of these beds, other ore ridges, as those of Rice's bank and Brewster's mines, near Esom Hill, form a continuation of the chain extending southwest of Cedartown. North of Cedartown we find again, the continuation of the same condition at Waddell's bank, and at other pits near by. South of Cedartown, the Central Mining Company owns several banks east of Judkin's mills; southward of which occur the Cleveland, Pittman, Cox and Ray banks, containing considerable quantities of ore.

FISH CREEK DISTRICT.

At the northern end of this district, near Grady, there are two very extensive series of ore banks, the one belonging to the Cherokee Iron Company, and the other to the Central Mining Company. The occurrence of the ore here is identical with that in the Cedartown district, but the ridges are rather more elevated. Southward and on the peninsular tongue of Knox Dolomite, between Maclurea limestone exposures, there are various extensive deposits of ores, such as those of Hickman's or Simpson's mines (lot 1,015 21st district); of W. O. Morris' (lots 1,088, 1,133), and of Mrs. Morgan's and Mr. Winn's (lot 1,060, 21st district).

DISTRICT NORTHWEST OF ROCKMART.

On the red hills of the Knox Dolomite ridges, near Long Station (E. T., V. & G. R'y), northwest of Rockmart, adjacent to the junction of the Maclurea limstone valleys, there are several very large ore deposits. Those near Long Station belong to the Central Mining Company; and beyond are the Randall and Cochrane mines. The general condition is similar to that at Cedartown. Between these deposits and those southwest of Rockmart, in which one would expect to find ore banks, there appears to be a considerable gap.

NOTE.—The ore ridges are usually subordinate to the great ridges of the Knox formation. Whilst the trend of the chain of ore hills may be often that of the general ridges of the country, yet the individual ridges have a direction frequently at right angles to the general trend. In the proximity of the ore deposits, to the edge of the Knox Dolomite formation, they may be frequently a mile or two distant; or they may rise as insular ridges through the newer formations.

ORES OF THE IRON-LIMESTONE SERIES.

The exposures have already been described. Whilst portions of the bed are still partly calcified, yet the greater proportion of the

beds, as at present known, are almost entirely converted into iron ore, which is much sought for. This chain of ore deposits is situated above the Maclurea limestones and beneath the slate beds, to the southeastward. The largest of these deposits appears to be that at the Deaton (Couper) mine (lots 81 and 64, 18th district), where the limestone formed the roofs of great caverns, which, in collapsing, have produced heterogeneous heaps of ore filling the old chambers. In this mine, the ore is known to have a depth of forty feet at least, intersected with the limestone walls of the ancient caverns. The whole mass of fallen material is a workable ore deposit.

The Central Mining Company has similar deposits on and adjacent to lot 1076, 18th district. The ore beds are continuous and are known to reach to a depth of twenty feet, but are covered by from four to eight feet of ferruginous clay.

Similar deposits are found on lots 784 and 728 (Carleton), 873 (Haton's) and 928 (Jones'), all in the 18th district.

The ore is entirely unlike that of the Knox group. The material is limonite and usually of a yellowish color. The more desiccated and redder varieties are frequently magnetic. This is scarcely to be wondered at, as the rock is slightly metamorphic, and thus it would appear that the iron ore dates its origin to a time anterior to the metamorphism of the slates which probably overlie these beds farther south. The material of the ferruginous earth, in some respects, resembles other iron-bearing earths of the county, but the pebbles and iron-ore blocks contained therein are fragments of laminated rocks, and not concretions. Some of the intercalated ore layers are converged into a soft ochre deposit, as is also the case with some of the overlying beds.

ORES OF THE LOWER CARBONIFEROUS CHERT.

About six miles southwest of Cedartown, on Mr. West's and adjacent properties, there are brown ores associated with chert masses. On lot 324 of the 2d district we find the siliceous ore in beds. These deposits are on the northwest side of the ridge, and in proximity to the junction line between the different formations. This ore has a peculiar character of its own, somewhat approaching hematite in its appearance, and is very compact. The quantity is considerable, but there have been no workings, nor have I seen any analysis of these ores.

ANALYSES OF THE ORES.

In many places, manganese in small quantities is associated with the brown ore. Occasionally zinc is also included. Very little sulphur is present. The phosphorus varies even in neighboring pits. Or-

dinarily, it is in sufficiently small proportion to not interfere with the use of the ore. The average quantity of metallic iron in the extracted ore usually exceeds fifty per cent., and the reduction of the quantity of the metal arises from clay and sand that is not entirely separated from the ore, which is everywhere in demand.

ANALYSIS OF POLK COUNTY ORES FOR THE CHEROKEE IRON COMPANY.

BY ERNST. SJOSTEDT, CHEMIST.

	I.	II.	III.	IV.	V.	VI.
Silica	8.01	15.95	9.27	12.18	10.60	10.19
Alumina	13.21	17.01	41.48	5.52	3.71	6.85
Oxide Iron	70.57	57.00	78.85	71.28	80.14	75.14
Lime	1.27	1.13	1.61	2.99	1.49	2.41
Magnesia	0.42	0.22	0.48	0.50	0.11	0.41
Manganese	0.12	0.93	0.40	0.27	0.38	0.35
Phosphoric Acid	0.58	2.17	0.91	1.11	0.88	1.00
Water	5.01	4.88	4.20	6.08	3.08	3.51
Iron	49.40	39.90	55.00	49.9	56.1	52.6
Manganese	0.09	0.72	0.31	0.22	0.22	0.27
Phosphorus	0.253	0.949	0.399	0.491	0.386	0.438

No. I, Roasted ore from Grady's Bank. II. Roasted ore from Peek's Bank. III, V, VI. Ores used on three succeeding days in furnaces. IV. Washed ore.

These iron ores, being variable, yield metallic iron, containing from 0.20 to 0.75 per cent. of phosphorus.

THE COMPOSITION OF THE ETNA ORES,

as shown by the analyses furnished by Col. Hamilton:

	Per cent.
Iron sesquioxide	81.26
Manganese sesquioxide	0.43
Aluminia	1.12
Lime	0.12
Silica	5.79
Water	11.45
Phosphorus	0.05
Sulphur	0.01
	100.23
Metallic iron	56.88

The analyses of the ores obtained at eleven other ore banks yielded:

	Per cent.
Metallic iron, from	58.45 to 51.10
" manganese, from	0.20 to 5.60
Silica, from	2.40 to 7.87
Phosphorous, from	0.147 to 0.858

One analysis showed 16.39 per cent. of silica. Another analysis gives 1.396 per. cent. of Phosphorus, which generally falls below half of one per cent. The above analyses were made by L. S. Clymer, in the labarotory of Messrs. Cooper & Hewitt, Reegelsville, Pa.

The analysis of the iron produced in May, 1890, showed the presence of:

	No. 4.	No. 5.
Silicon	0.253	0.337
Manganese	0.144	0.124
Phosphorus	0.412	0.393
Sulphur	0.000	0.000

THE ANALYSIS OF THE ORES FROM DEATON (COUPER) MINE IN THE IRON-LIMESTONE SERIES.

	I.	II.
Metallic Iron	48.56	49.32
Silica	14.25	11.04
Phosphorus	0.363	0.335
Sulphur	Trace.	.....
Titanium	0.011	.....
Water	1.30	2.53
Lime	.....	0.73

One individual analysis gave iron 53.12 per cent., and others showed the phosphorus below 0.3 per cent.

Whilst zinc minerals were not observed along with the iron ores in the field, yet their presence is demonstrated by the accumulation of zinc sublimates beneath the funnel of the furnaces. Thus, when the Cherokee furnace, at Cedartown, was blown out about 1880 (at that time, a charcoal furnace) about twenty thousand pounds of a product of the following composition was found accumulated under the funnel.

Zinc oxide	82.443 per cent.
Alumina and iron	3.700 per cent.
Coal dust	3.140 per cent.
Alkalies (by difference)	9.857 per cent.
Sulphur	0.203 per cent.
Cadmium oxide	Trace.
Insoluble matter	0.660 per cent.

FURNACES.

In Polk county, there is a furnace at Cedartown—Cherokee Iron Company—whose capacity reaches twenty thousand tons a year. It has been in operation for many years, having been originally built as a charcoal furnace. The product is a high grade of foundry iron. One other furnace occurs in the county, the Etna furnace, situated near the Alabama line. This is a charcoal furnace, with a capacity of about ten thousand tons a year. Just over the Alabama line, there are also extensive ore deposits and several furnaces.

THE ORE PRODUCT.

Two furnaces thus named, when running full time, consume nearly sixty thousand tons of ore a year. Nearly 200,000 tons of the Polk county ores were shipped (in 1890) to Alabama and Tennessee. There is a constant demand for the brown ores, as they are much sought after for mixing with other kinds of ore. They command a good price.

Until comparatively recently very little ore was shipped or used, except such as could be screened, as washers were not then introduced. This was due to the mining operations being generally performed by small contracts. Nowadays, the larger companies have put up improved washing machinery, whereby a greater yield, at lower cost, is obtained, and, at the same time, a better quality of ore. The cost of mining varies greatly. In one case (the Deaton mine), the ore is put on board the cars at fifty cents a ton; in other cases, as much as a dollar a ton is paid for the cost of raising. The net price received for the ore varies—about one dollar and fifty cents per ton. This last price is that obtained at the Deaton mine, which is shipping two thousand tons per month.

NOTE ON THE ORE DISTRIBUTION.

In the references to individual mining properties in the preceding pages, the notice of them was incidental, as being the easiest way of locating important positions. Many of the named companies possess considerable numbers of ore banks. There are also many unnamed deposits of value, situated in the general belts, whose position is easily recognized along the chains of ore banks named. Outside of these general belts, on many of the chert hills, there are numerous deposits of ore, but not in sufficient quantities to be of value, although here and there, some may yet be found of value.

OCHRE WORKS.

There is in process of construction, at Rockmart, an establishment for the manufacture of ochre and other paints from the abundant ferruginous clay.

MAGANESE ORES.

There are several localities in Polk county, where oxides of manganese occur, but there is no mining, although just beyond the limit of Polk, in Floyd county, a large mine is now being operated by Mr. Couper. Accordingly, the consideration of manganese ores scarcely falls within this report. Still, it is proper to add that the manganese occurs in the Knox Dolomite ridges more or less associated with the partially disintegrated rocks, as well as in the risidual clays like the richer deposits of iron ore. Hence, the manganese often occurs in the gray ridges. Deposits are found south of Cave Spring. Near the county line, about seven miles north of Cedartown, manganese occurs upon the property of Mr. Stokes. About a mile from Hickman's mines, on the farm of Mr. G. W. Morgan, manganese was also found. Again, in the valley near "Hematite," a mixture of iron and manganese was seen. The superficial indications are frequently confined to black or dark bluish stains, owing to manganese powder being mixed with the clay. Pockets of manganese ores also occur at Etna, yielding from 45 to 50 per cent of metal.

CHAPTER XXI.

BUILDING MATERIALS.

LIMESTONES.

The Maclurea limestone is a compact, fine grained rock, varying from a light bluish to a dark bluish gray color; indeed, it is a sort of a marble. In numerous places in the valleys, which have been described before, the limestone is available for unlimited local use, but as it is situated near the drainage level, it could not be quarried cheaply enough for extensive shipment, as there are some points in the county, which are more favorable for its extraction. Near Rockmart, and northeastward, there are many ridges which are particularly favorable for the working. Thus, at Devitte lime ridge, about five miles northeast of Rockmart, the rock is but thinly covered with earth and the quarries have a vertical face of forty or fifty feet. The location is very favorable for its cheap extraction, and large quantities have been shipped for furnace purposes, at forty-five cents a ton. In this region, there are various other available lime ridges. The quality varies somewhat between the different ridges, but they are of high grade, either for furnace purposes, or for lime, as may be seen from analyses on page 110 of this report.

As a building stone, it is good, and many portions of the beds have a beautiful color. It is a wonder that more of it has not been used in competition with granite. Its hardness has, no doubt, to some extent interfered with such use, as it is more difficult to work than many other limestones, but yet it is much softer than granite, and quite as durable. It contains but little iron, and therefore does not change its color.

SLATES.

As a geological formation, the Nashville or Rockmart slates have already been described. As an economic product, only the ridges, can form suitable locations for quarries. The slates in the ridges are hard, and are frequently very little affected by weather, except the thin surface coating. At other times, the surface slates are weathered to a depth of twenty feet. In many localities, the slates are consequently unavailable, or where available, they are found to be unsuitable for splitting. But in the ridge at Rockmart, good cleavable slates

have been quarried for many years. When viewing the vast heaps of waste material, unfavorable impressions might at first be formed, but the wastes in every slate quarry are equally large. These, however, might be somewhat reduced with more systematic methods of working. The available slate deposits at Rockmart belong to various individuals, and the quarrying could be more effectively carried on if the boundary lines were removed by a combination of interests. The three principal owners are Col. T. F. Dever, the Seaborn Jones estate, and theRockmart Land Improvement Company.

At Rockmart, a variety of banded indurated clay is found. This can be sawed, carved or turned, is of a yellowish color, and capable of manufacture into a variety of ornamental work. When ground it makes a mineral paint.

BRICK CLAYS.

The clays of the county are not everywhere suitable for brick purposes. Those of the red hills contain too much iron, and of the gray hills too much sand, still, fair bricks are obtained from some of the valley deposits, which appear to have a swampy origin, and from these the best local bricks are made.

SANDSTONE.

Ordinary sandstones do not occur in Polk county. Southeast of Esom Hill, a compact quartzitic rock is found. On Indian Mountain, there is abundance of beautiful fine-grained quartzite. This is a metamorphic sandstone. It occurs in beds of any desired size. Whilst a most durable rock, its great hardness makes it a costly building material. Beds of cherty rock occur. These, however, could not be used as a good building material; but when broken up, or when the loose surface fragments are obtained, they make serviceable macadam for roads. Such deposits of chert are widespread.

CHAPTER XXII.

THE SOILS.

A report upon the value of the soils in the different belts cannot be given, as the assistance of a chemist for analytical work has, so far, not been available; however, the general distribution of the soils and their relation to the geological formations can be stated. The popular classification of the soils, into gray and red lands, is somewhat misleading, and is not sufficiently specific, for the character of the gray and red lands of the Palaeozoic formations of Polk county are entirely different from those of the metamorphic formations of Middle Georgia, or, again, those of South Georgia. The soils of Northwest Georgia have been derived from schists, slates and limestones, but these have produced varieties depending upon their origin.

THE CAMBRIAN SOILS.

These do not form a large factor in the agricultural features of Polk county, as they occupy but a few square miles in the northwestern part. The soils amongst the sandstones of Indian mountain are confined to more or less isolated patches. Farther down the slopes, the slaty ridges are covered with a thin soil, but lower still we have the valley of Etna, etc., more or less composed of soils derived from the Upper Cambrian shales, which are of good quality as the shales were more or less calcareous.

THE KNOX DOLOMITE AND OTHER SOILS.

These are of two characters—the valley red lands and red hills; and the gray ridges and cherty hills. The former of these classes constitute some of the best lands in the State. The cherty gray uplands are often of inferior quality. We find the red lands more largely developed in the southern than in the northern part of the county. The red valley lands in the southern and eastern part of the county often graduate into the limestone valley lands of the overlying Maclurea division; these, together, constitute our best soils.

Overlying the margin of these fertile limestone lands, there are the several districts occupied by the Nashville slates. These soils are sometimes of good quality, but very often they are thin and indifferent.

On the metamorphic ridges of Dug Down mountain, we have indifferent soils overlying the slates, which often come to the surface.

From this brief description, it will be seen that the soils in the county are very variable, from some of the best lands in the State to others which are indifferent. However, all of the cherty ridges derived from the Knox Dolomite could not be classified as poor land, although some of them are very light and indifferent. The cherty gravel is superficial, and when the country comes to be more densely populated, these stones will be removed as is done elsewhere.

THE TIMBERS.

The most valuable timbers are the oaks and the pines, which still exist in considerable quantities, although where near to railways, they have been largely cut off; still, there are many ridges which are yet uncultivated, and in their almost original condition, and support a sufficient supply for local manufacture and other uses.

CHAPTER XXIII.

WATER-POWERS.—ROADS.

WATER-POWERS.

A number of small water-powers, which, however, have a great head of water, are found along the slopes of Dug Down mountain; such as those of Hightower mills, and Simpson's mills, where the fall reaches forty to sixty feet, and more, thus giving power to the compartively small streams. Several other small powers are scattered throughout the county, such as at Judkin's and Young's mills south of Cedartown, and at Rockmart and Cochran's mills in the northeastern part of the county.

ROADS.

Throughout Polk county the valley roads have often good grades, but over the ridges they are often steep. The roads over the slaty formations are usually good. Those over the decayed limestone formations are liable to be cut in deep ruts during the wet seasons. The roads over the more cherty formations are more certain. Owing to the various distribution of chert, and the limestones, valuable material for road-making would be available in many places.